Detectors for the European Spallation Source: The Story so far ....

- ESS
- Instruments@ESS
- Detectors@ESS

"Detector Technology and Systems Platform"
19 November 2012

Richard Hall-Wilton
Detector Group Leader, ESS
On Behalf of the ESS Detector Group

Caveat Emptor

- Presented here is a snapshot
- Process is still evolving rapidly
- Subject to change ...

Neutrons

What is Neutron Scattering Science?

Complexity

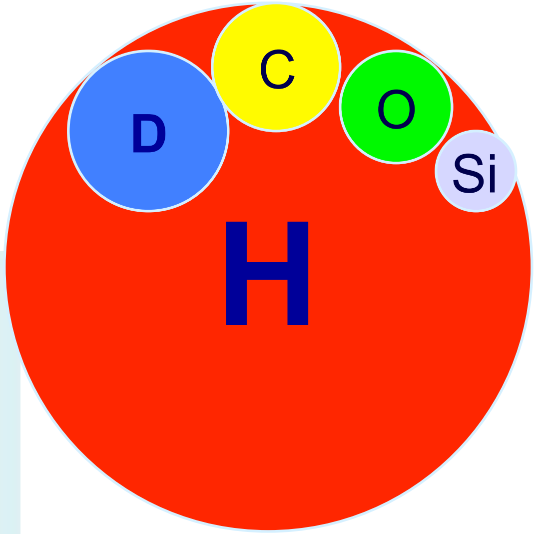
Neutrons are
- low energy
- non-damaging
- penetrating
- broad wavelength range

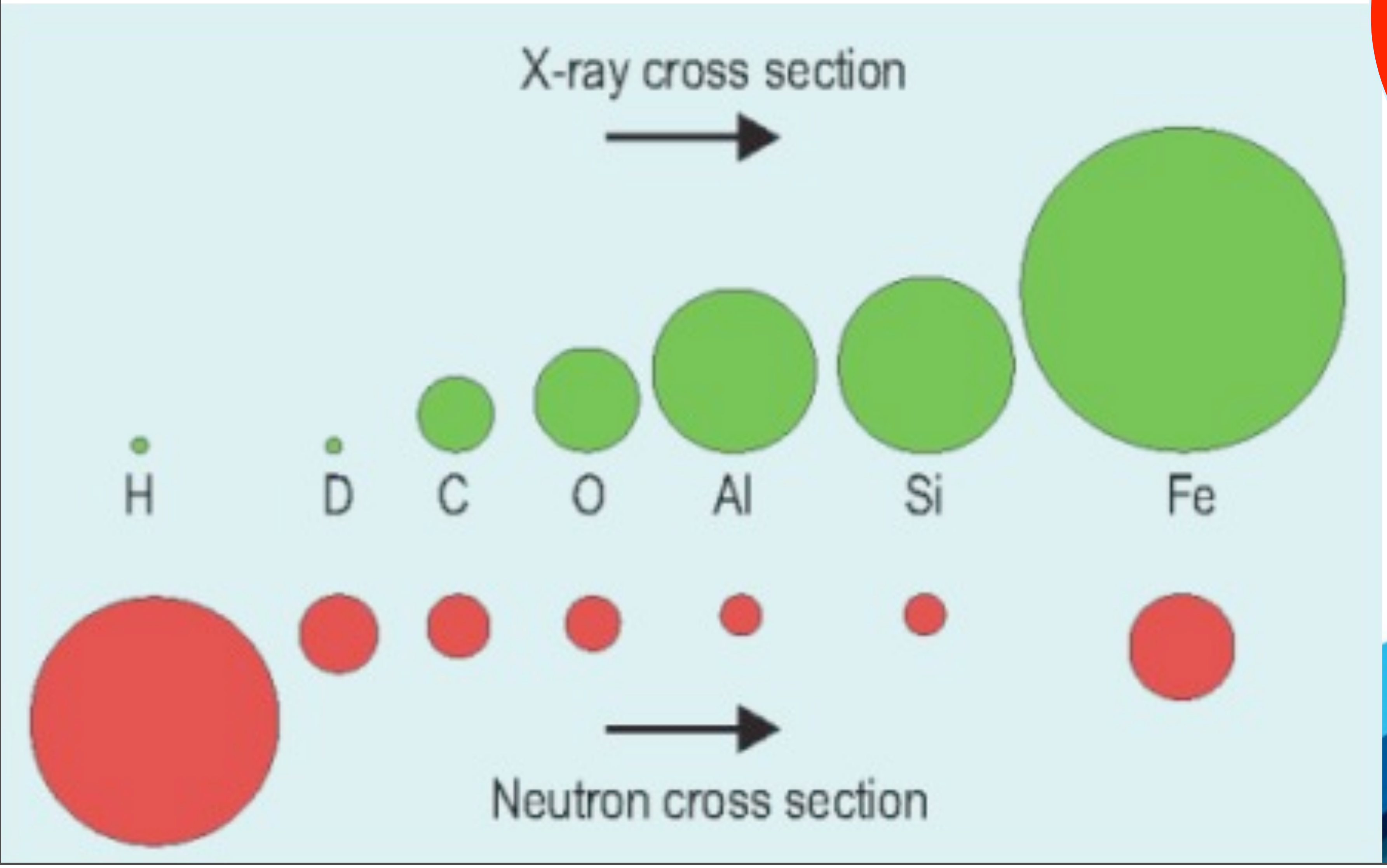
ESS high intensity allows studies of
- complex materials
- weak signals
- important details
- time dependent phenomena

Details/Resolution

Why Neutrons?

1) Ability to measure both energy *and* momentum transfer
   Geometry of motion
2) Neutrons scatter by a nuclear interaction => different isotopes scatter differently   H and D scatter very differently
3) Simplicity of the interaction allows easy interpretation of intensities
   Easy to compare with theory and models
4) Neutrons have a magnetic moment





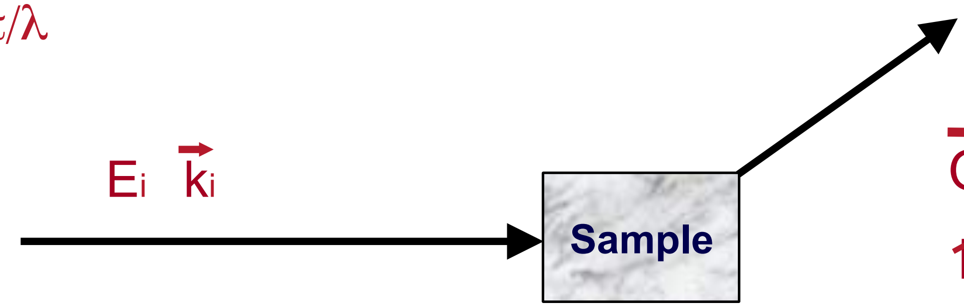
What is measured?

momentum = $\hbar\vec{k}$ energy = $(\hbar k)^2/(2m)$

$k = 2\pi/\lambda$

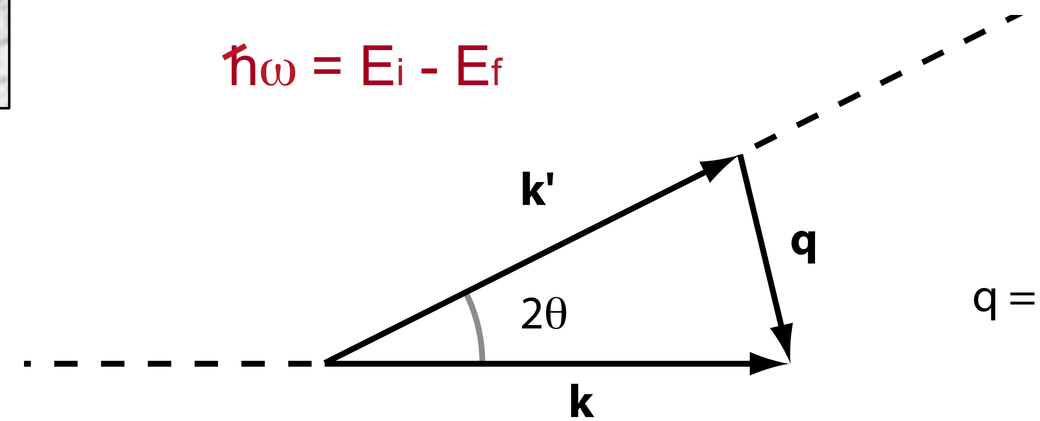
E_f $\vec{k}_f$

E_i $\vec{k}_i$



$\vec{Q} = \vec{k}_i - \vec{k}_f$

$\hbar\omega = E_i - E_f$



$$\sin\theta = \frac{|\mathbf{q}|}{2}\frac{1}{|\mathbf{k}|}$$

$$q = 2k\sin\theta = \frac{4\pi}{\lambda}\sin\theta$$

Measure number of neutrons scattered as function of Q and ω

Intensity of scattering as function of Q is related to the Fourier transform of the spatial arrangement of matter in the sample (except imaging ...)

Need a good efficiency, position and energy/time resolution
Good signal/background

The European Spallation Source

EUROPEAN SPALLATION SOURCE

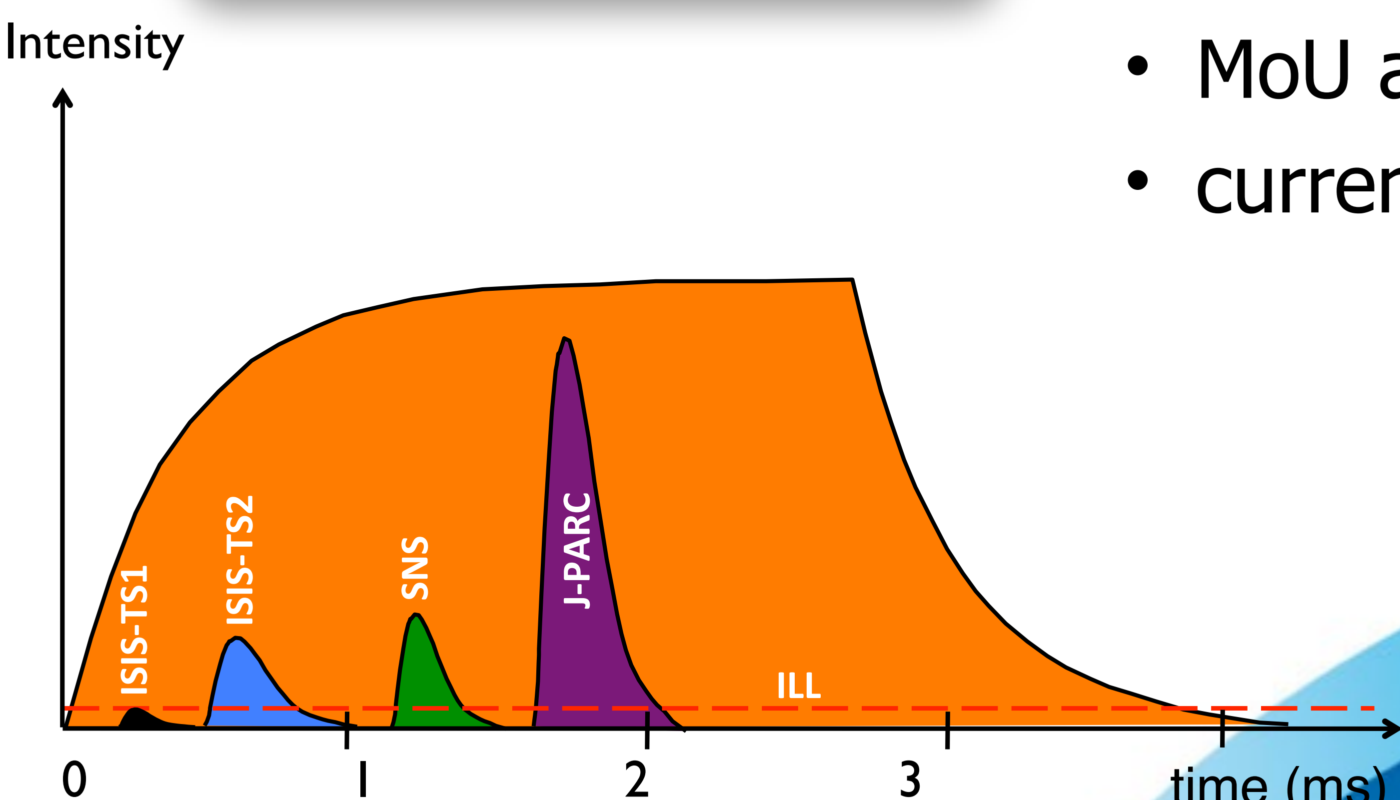
The ESS Headlines

- ESS will be the world’s best source of neutrons for the study of materials
- ESS will be 30 times brighter than ILL, the worlds’ best research reactor
- ESS will be 10 times more intense than SNS, the world’s most powerful spallation source
- ESS will produce first neutrons in 2019

ESS project: key facts

- 5MW long-pulse neutron source.
- First neutrons in 2019 on 7 instruments.
- 22 instruments by 2025
- ESS will be user facility.

- Total cost 1478 M€; funding negotiation
- MoU agreed with 17 european countries
- currently in pre-construction phase

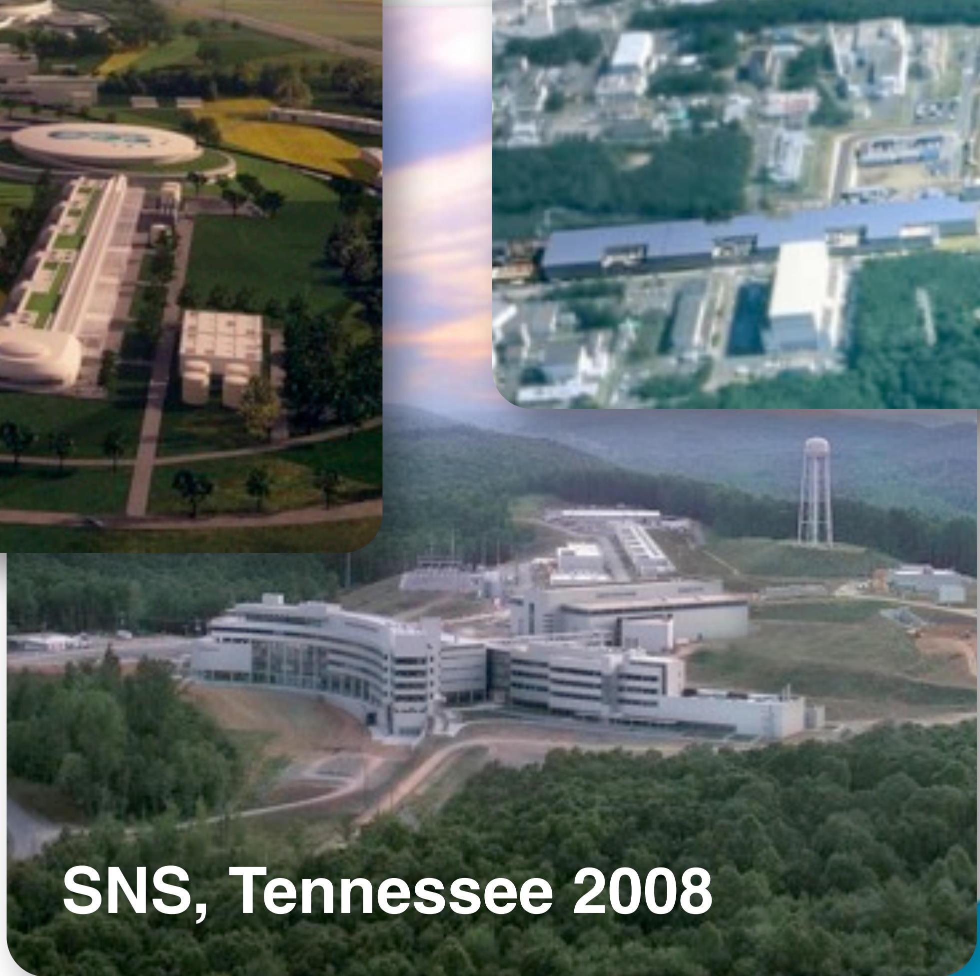


EUROPEAN SPALLATION SOURCE

High-intensity spallation sources

ESS, Lund 2019

J-Parc, Tokai-Mura 2008



SNS, Tennessee 2008

OECD 1999:
”One powerful
spallation source
in every global region”

ESS Project Phases

The Design Update phase 2010 – 2012

(Technical Design Report to be submitted Feb 2013)

Prepare to build 2013 - 2015

The Construction phase 2015 - 2018

The Completion phase 2019 - 2025

The Operations phase 2026 - 2066

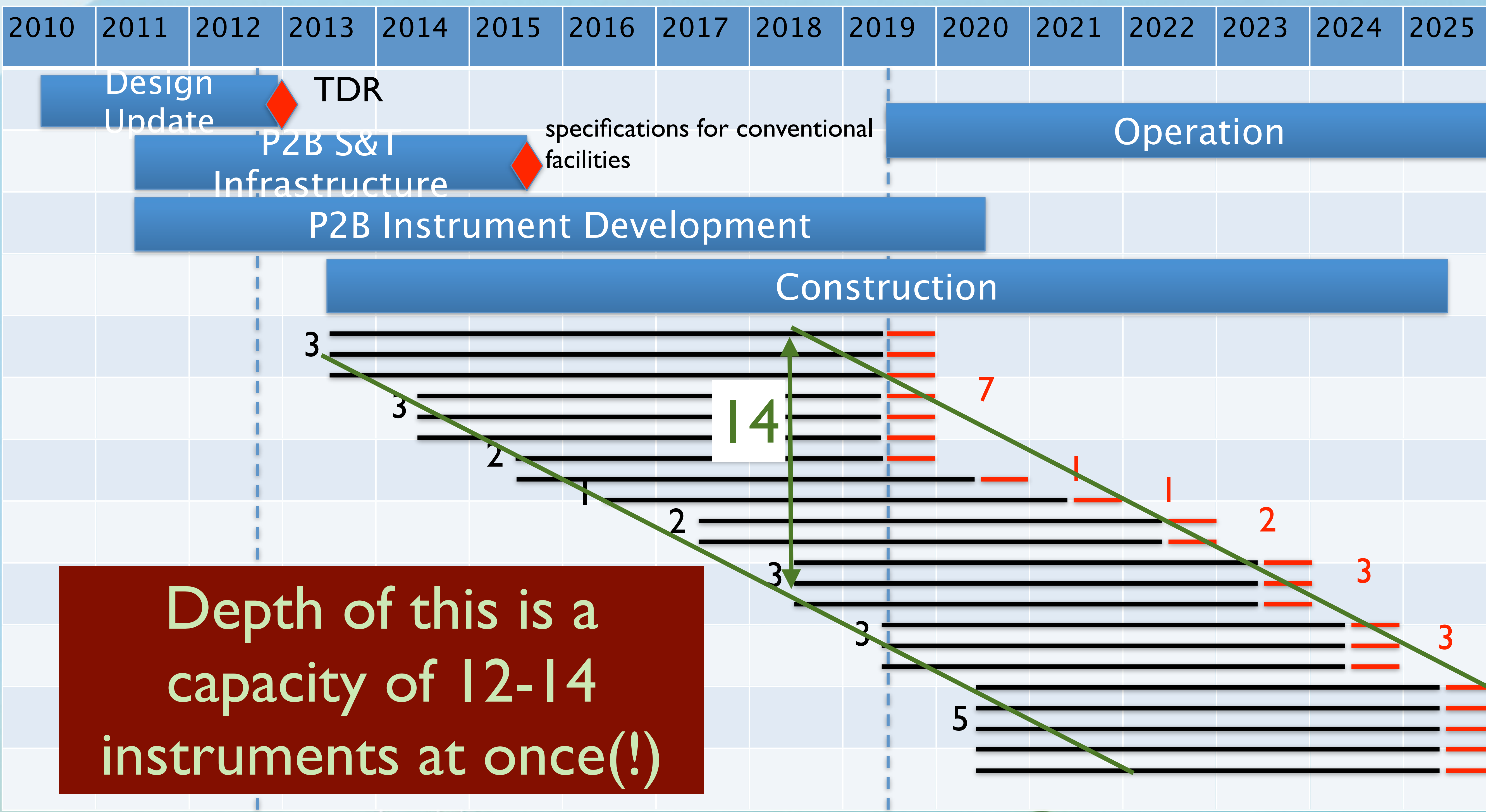
The Decommissioning phase 2067 - 2071

The ESS Site

23 October 2012

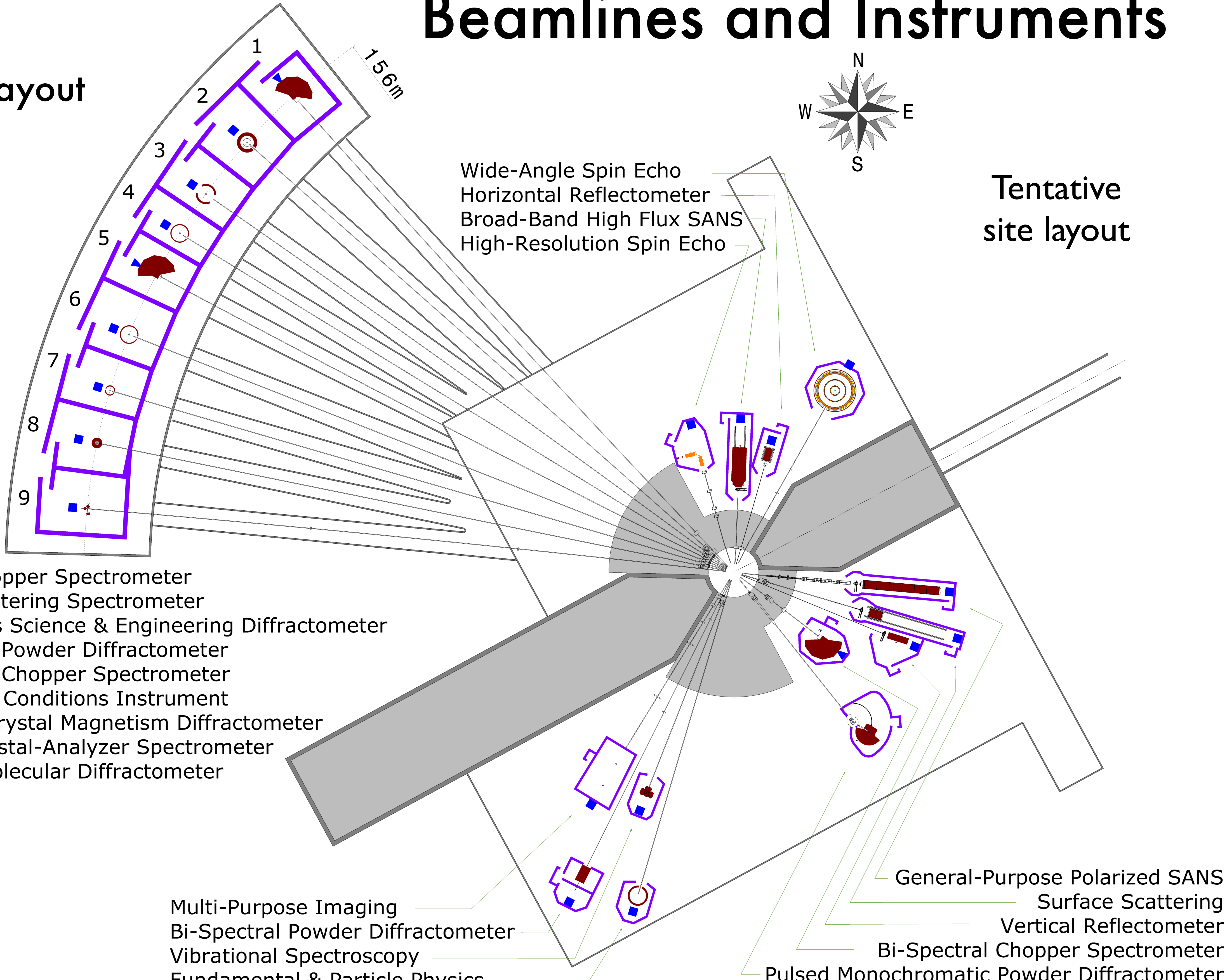
ESS Timeline

2019: First 7 instruments on-line
2025: Full suite of 22 instruments on-line



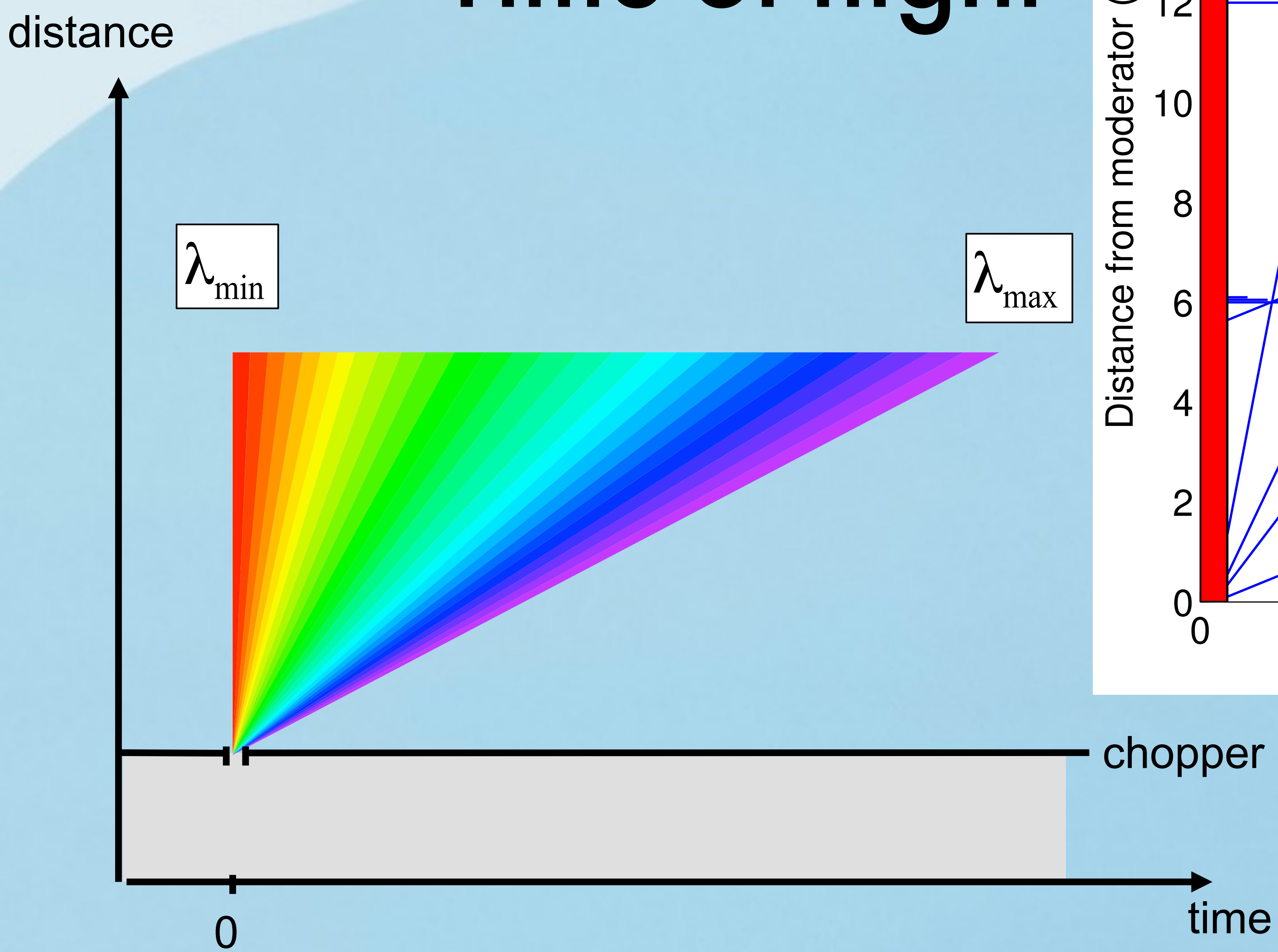
Beamlines and Instruments

- Tentative site layout
- Baseline suite
- 22 instruments



1. Cold Chopper Spectrometer
2. Backscattering Spectrometer
3. Materials Science & Engineering Diffractometer
4. Thermal Powder Diffractometer
5. Thermal Chopper Spectrometer
6. Extreme Conditions Instrument
7. Single-Crystal Magnetism Diffractometer
8. Cold Crystal-Analyzer Spectrometer
9. Macromolecular Diffractometer

Neutron Time-of-flight



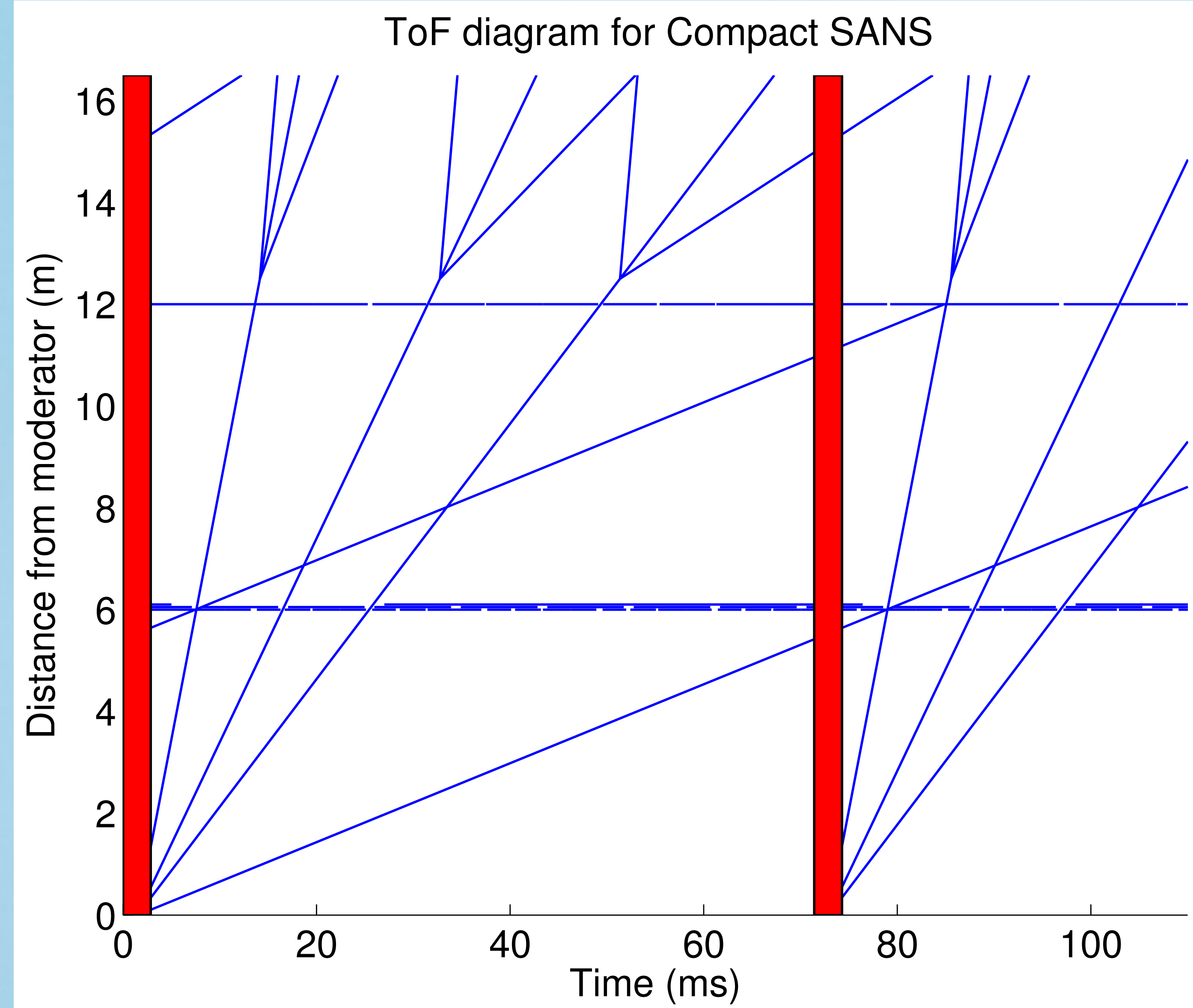


Figure 9: *Time-of-flight diagram of the variable-burst time scheme of the chopper ToF SANS for ESS. The position of the pulse-shaping chopper, the contaminant removal chopper, and the frame overlap chopper is at 6 m, and the monochromating chopper is at 12 m. The red areas indicate the prompt pulse. See figure 10 for a closer look at the chopper system at 6 m.*

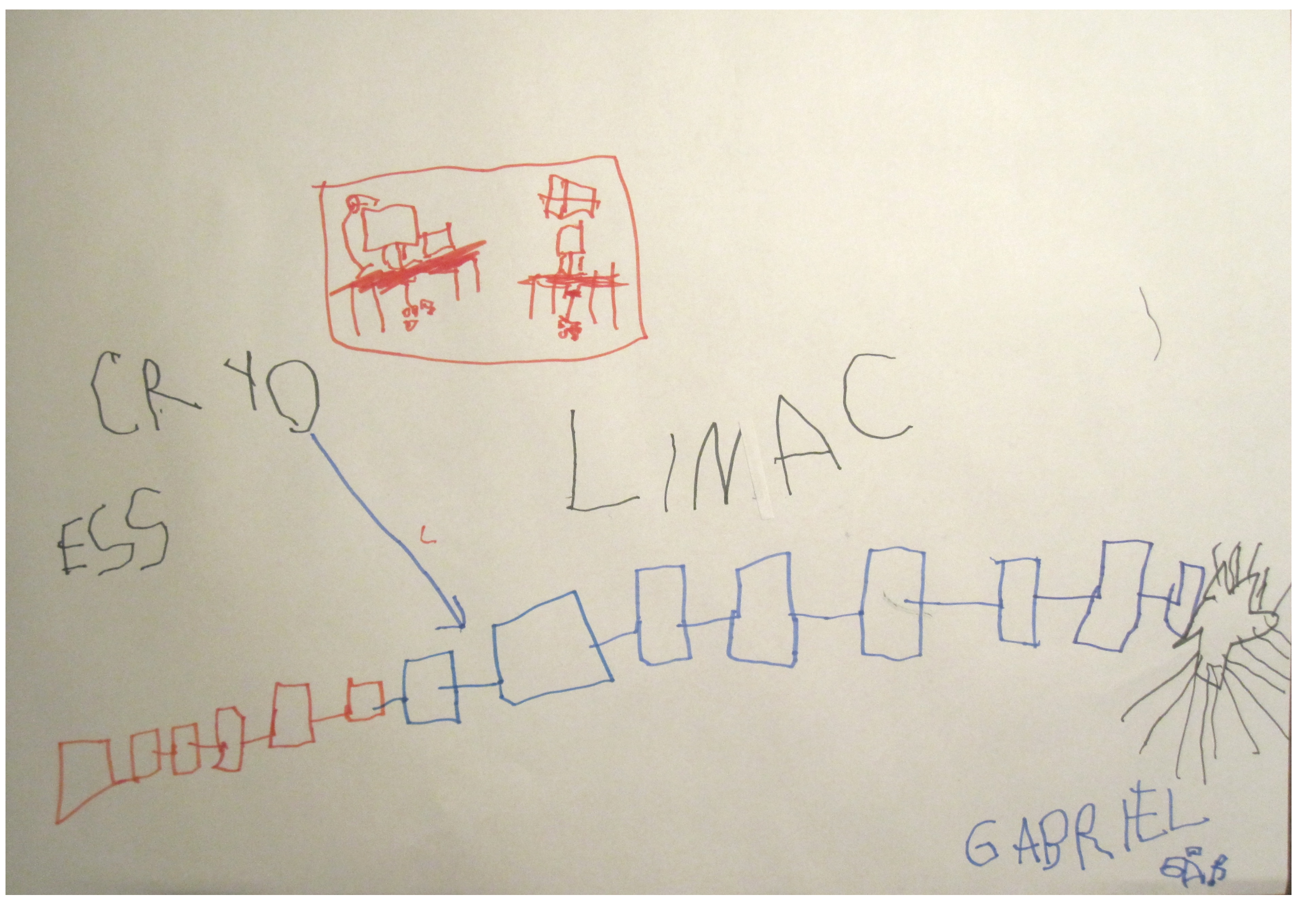
- Almost all instruments use Time-of-flight of neutrons to determine wavelength of neutrons
- Timing and time shaping is typically a key part of the definition of the neutron beam
    - Reminder: ESS is a long pulse source
- Means that detectors need good time resolution (us+)
- Wavelengths ca. 0.3 - 20 Angstroms, energy ca. meV
- Access energy of neutrons from statistical methods: see later

ESS Technical Design Report

- ESS TDR due in Feb'13
- Significant increase in maturity and detail
- Input to governmental agreement
- Will serve as a baseline for construction

Feb '12 →

ESS Conceptual Design Report



ESS Technical Design Report

Editors: S. Peggs, Kreier, ...

Contributors: Andersen, et cetera .....

Figure credits: Advanced Cyclone Systems, et cetera .....

DRAFT 3

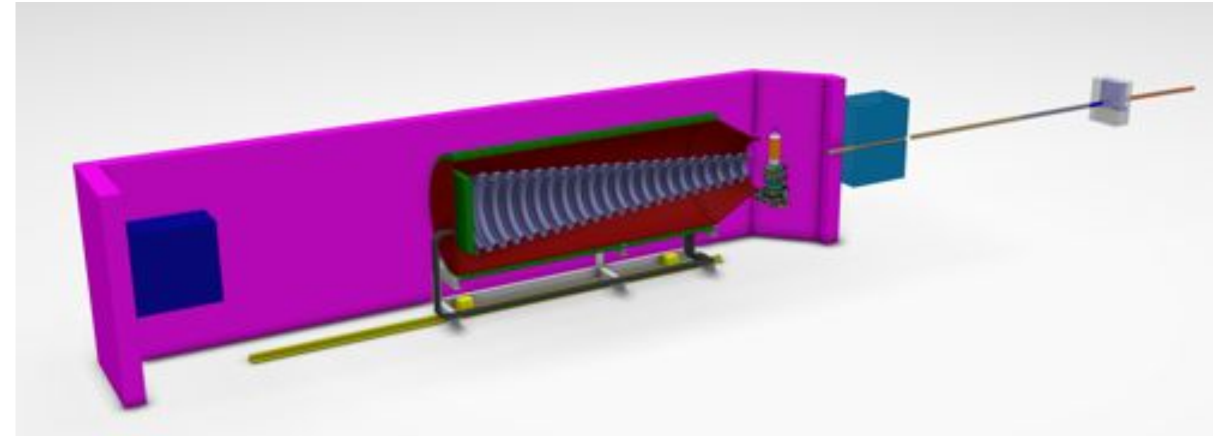
*** THIS INTERMEDIATE DRAFT IS ***
*** UNDER ACTIVE DEVELOPMENT ***

October 31, 2012

ESS Instrument Proposal Round 2013

- Proposal round closed yesterday
- 4 proposals received
- An imaging beamline proposed in addition to the below
- Up to 3 instruments will be chosen by mid 2013

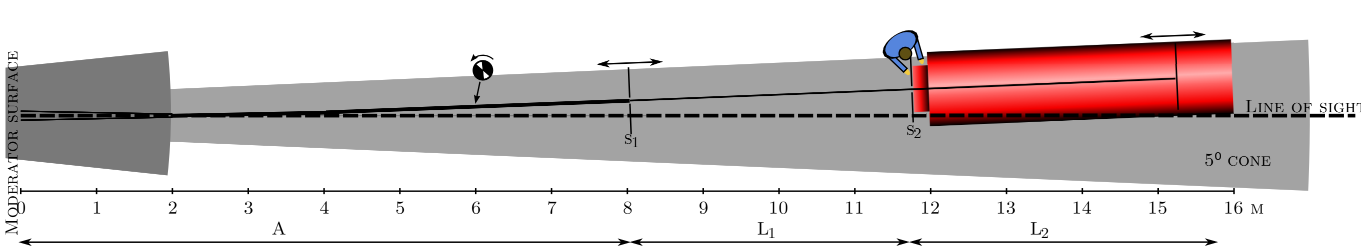
ESS Instrument Construction Proposal
LoKI - A broad-band SANS Instrument



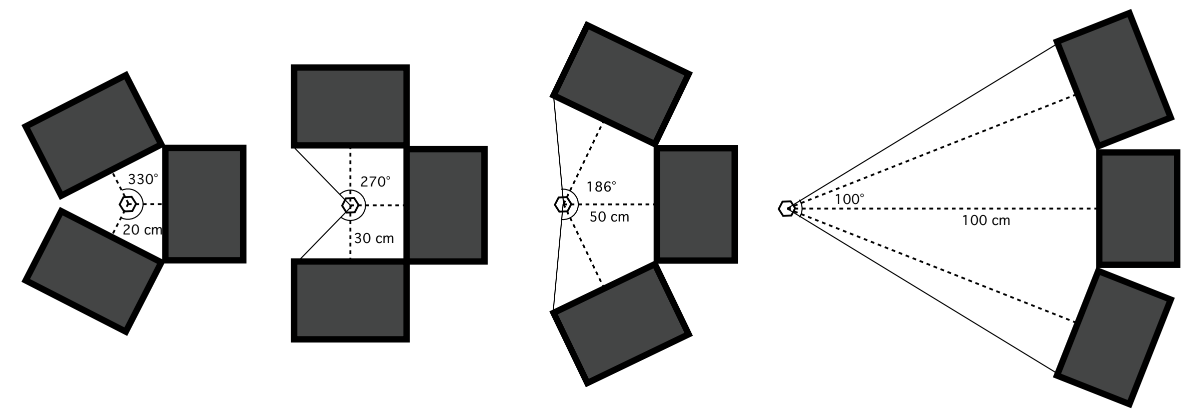
	Name	Affiliation
ESS Instrument WP coordinator	Andrew Jackson	ESS
ESS Partners	Andrew Jackson	ESS
	Kalliopi Kanaki	ESS

ESS Instrument Construction Proposal
Compact SANS Optimised for Biological Samples

K. Klenø[1], S. Kynde[1], G. Nagy[2], N. Skar-Gislinge[1], K. Mortensen[1], K. Lefmann[1], J. Kohlbrecher[2], L. Arleth[1],
[1] *Niels Bohr Institute, University of Copenhagen, Denmark*
[2] *SINQ, Paul Scherrer Institute, Switzerland*



ESS Instrument Construction Proposal
Macromolecular Diffractometer

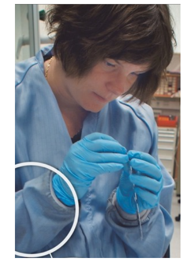


	Name	Affiliation
ESS Instrument WP coordinator	Esko Oksanen	ESS
ESS Partners	Esko Oksanen	ESS

Detectors for the European Spallation Source

The ESS Detector Group (Nov 2012)

Anton Khaplanov



Carina Höglund

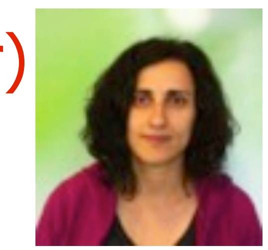
Mewlude Imam (Sep 12)

Linköping
SE

ILL
FR

ESS-Lund
SE

Richard Hall-Wilton (group leader)
Kalliopi Kanaki (Jun 12)
Thomas Kittelmann (Aug 12)



Detector Electronics Engineer (2nd round of interviews next week)
Technician (2013)

IFE
NO

Isabel Llamas
Xiao Xiao Cai
Thomas Haraldsen

Björn Nilsson
Julius Scherzinger

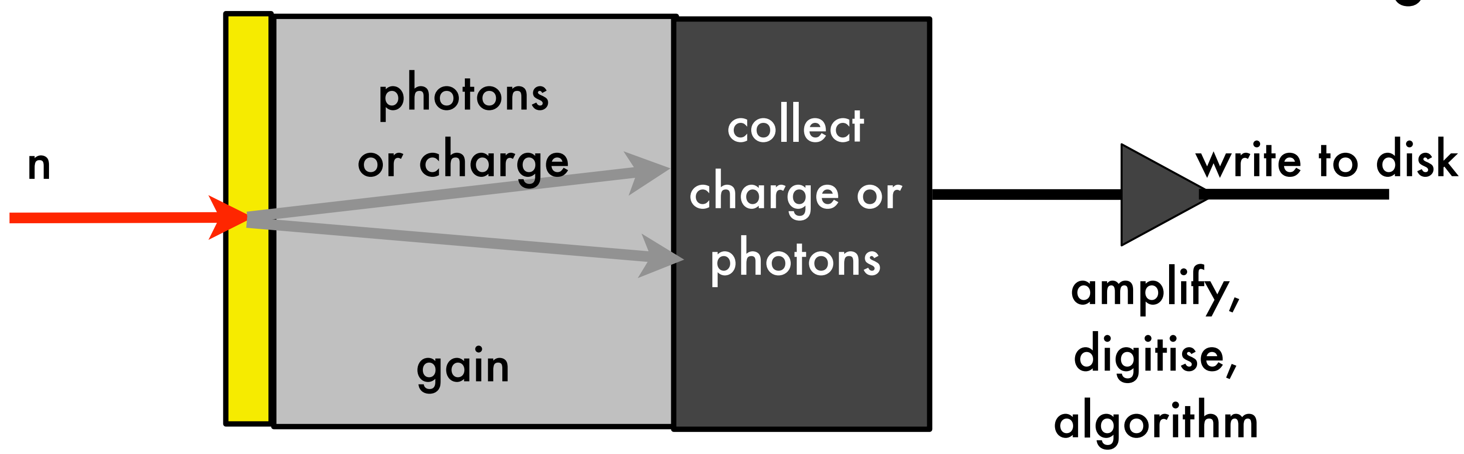
MAX-lab+
Lund U
SE

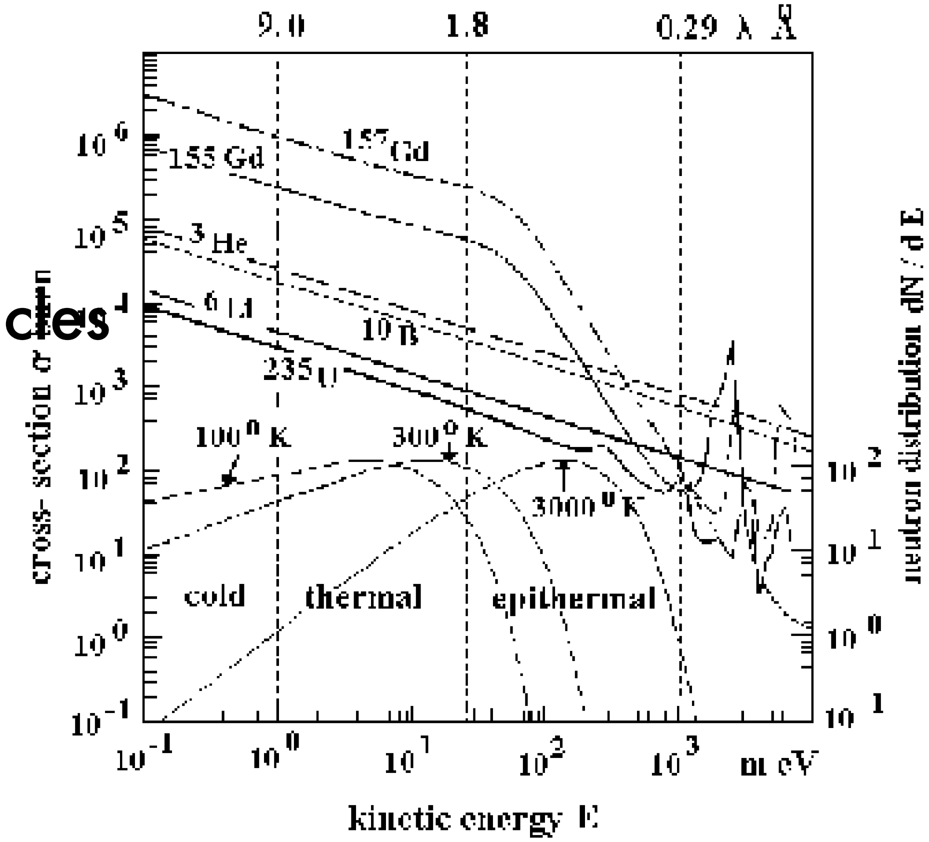
(31 Dec 2010, detector group comprised of ... Carina!)
RED colour: 100% of salary comes from ESS
BLACK colour: 50% from ESS, 50% local

The task for the ESS detector group

Basic Principles of Neutron Detectors

- Not possible to directly detect slow neutrons
- Use nuclear reactions to convert neutrons to charged particles



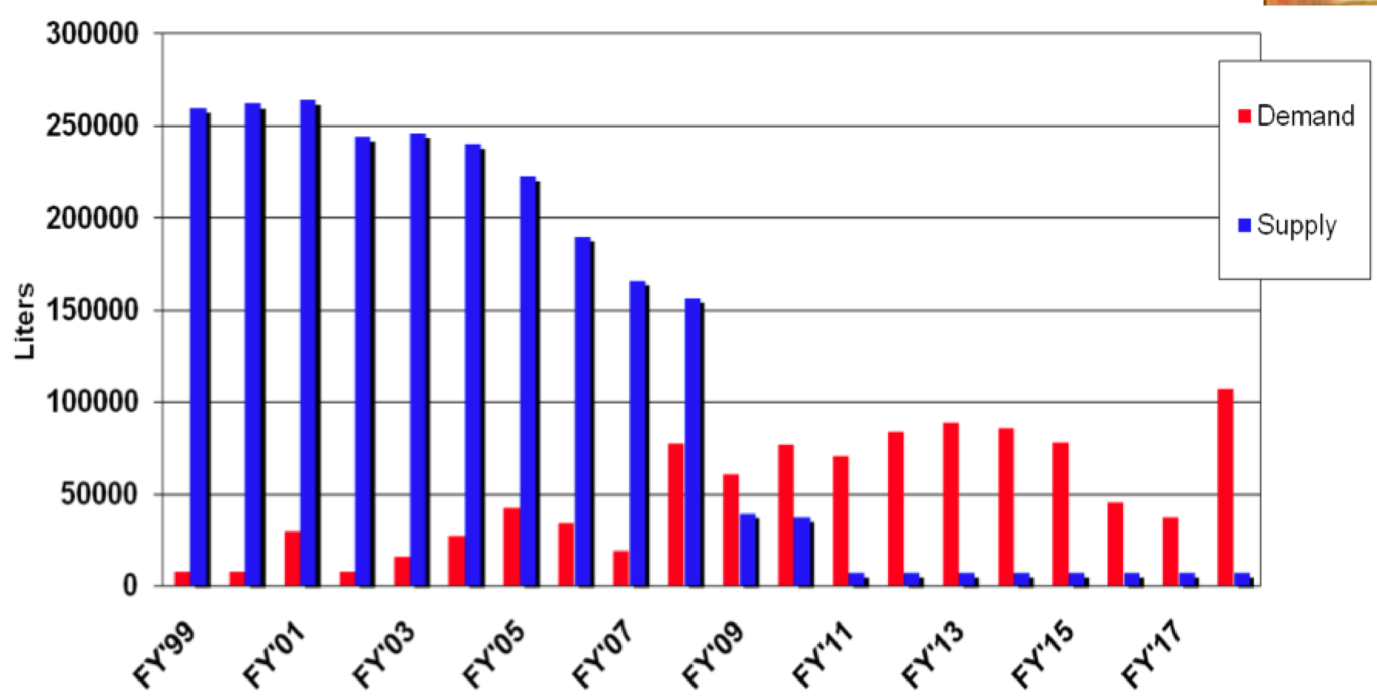


reaction	energy	particle	energy	particle	energy
n (^{3}He, p) ^{3}H	+0.77 MeV	p	0.57 MeV	^{3}H	0.19 MeV
n (^{6}Li, α) ^{3}H	+4.79 MeV	α	2.05 MeV	^{3}H	2.74 MeV
93 % n (^{10}B, α)^{7}Li +2.3 MeV + γ (0.48MeV)		α	1.47 MeV	^{7}Li	0.83 MeV
7 % n (^{10}B, α) ^{7}Li	+2.79 MeV	α	1.77 MeV	^{7}Li	1.01 MeV
n (^{235}U, Lfi) Hfi	+ ~ 100 MeV	Lfi	< = 80 MeV	Hfi	< = 60 MeV
n (^{157} Gd, Gd) e$^-$	+ < = 0.182 MeV	conversion electron			0.07 to 0.182 MeV

Table 1: Commonly used isotopes for thermal neutron detection, reaction products and their kinetic energies.

... Old News Now ...

He-3 Crisis



Little or None Available

Aside ... maybe He-3 detectors are anyway not what is needed for ESS? eg rate, resolution reaching the limit ...

Crisis or opportunity ... ?


... lots of work
ongoing now ...
Since ca. 2010

Home
Collaboration
Working Groups
Publications
News & Events
Imprint

Collaboration

Also a range of ongoing initiatives:

- Dedicated developments within ESS in-kind
- EU FP7 programs
  - eg CRISP, NMI3
- Local partnerships
  - eg Lund U, LTH, Linkoping U, Mid-Sweden U, MAX IV lab
- Grants through Swedish funding agency VR

Participating Facilities

ESS	European Spallation Source, Sweden
FRM II	Forschungs-Neutronenquelle Heinz M
HZB	Helmholtz Zentrum Berlin, Germany
ILL	Institut Max von Laue – Paul Langevi
ISIS	Science and Technology Facilities Co
JCNS	Jülich Centre for Neutron Science, Ge
J-PARC	Japan Proton Accelerator Research C
NIST	Centre for Neutron Research, USA
ORNL	Neutron Science Directorate, Oak Ridge National Laboratory, USA

"ESS In-kind"
- 4 DE groups:
- HZB
- FZJ
- HZG
- TUM/FRMII

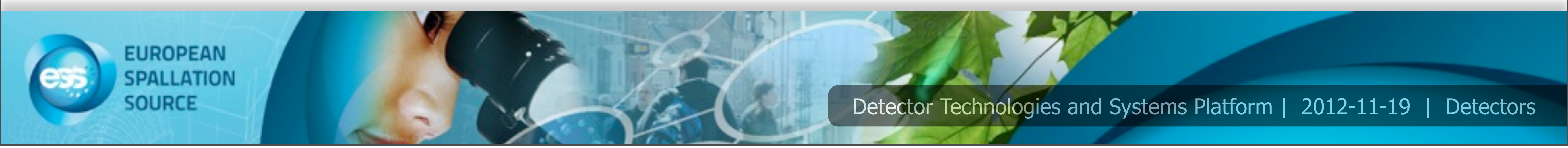
Coordination

K. Zeitelhack, FRM II, GER; E-Mail: karl.zeitelhack@frm2.tum.de

Working Group Coordination

Scintillation detectors:	N.J. Rhodes, STFC, UK;	E-Mail: nigel.rhodes@stfc.ac.uk
B10 – detectors:	B. Guerard, ILL, France;	E-Mail: guerard@ill.fr
BF3 – detectors:	T. Wilpert, HZB, GER;	E-Mail: wilpert@helmholtz-berlin.de

(... but no BF3 detectors for ESS ...)



Detector Requirements for Baseline TDR Suite

Instrument	Detector Area [m^2]	Wavelength Range [Å]	Time Resolution [μs]	Resolution [mm]
Multi-Purpose Imaging	0.5	1-20	1	0.001 - 0.5
General Purpose Polarised SANS	5	4-20	100	10
Broad-Band Small Sample SANS	14	2-20	100	1
Surface Scattering	5	4-20	100	10
Horizontal Reflectometer	0.5	5-30	100	1
Vertical Reflectometer	0.5	5-30	100	1
Thermal Powder Diffractometer	20	0.6-6	<10	2x2
Bi-Spectral Powder Diffractometer	20	0.8-10	<10	2.5x2.5
Pulsed Monochromatic Powder Diffractometer	4	0.6-5	<100	2 x 5
Material Science & Engineering Diffractometer	10	0.5-5	10	2
Extreme Conditions Instrument	10	1-10	<10	3x5
Single Crystal Magnetism Diffractometer	6	0.8-10	100	2.5x2.5
Macromolecular Diffractometer	1	1.5-3.3	1000	0.2
Cold Chopper Spectrometer	80	1 -20	10	10
Bi-Spectral Chopper Spectrometer	50	0.8-20	10	10
Thermal Chopper Spectrometer	50	0.6-4	10	10
Cold Crystal-Analyser Spectrometer	1	2-8	<10	5-10
Vibrational Spectroscopy	1	0.4-5	<10	10
Backscattering Spectrometer	0.3	2-8	<10	10
High-Resolution Spin Echo	0.3	4-25	100	10
Wide-Angle Spin Echo	3	2-15	100	10
Fundamental & Particle Physics	0.5	5-30	1	0.1
Total	**282.6**			

Estimates

Table 2.5: Estimated detector requirements for the 22 reference instruments in terms of detector area, typical wavelength range of measurements and desired spatial and time resolution.

- Specifications very varied
- Typically superior to what is presently state-of-the-art at existing sources

- In many cases, instrument performance dominated by S:B rather than raw specifications here

For larger detectors, pathway is becoming clearer ...

http://www.ill.eu/news-events/events/2nd-international-10b-bf3-detectors-workshop/home/

2nd International 10B BF3 Detectors' Workshop

Institut Laue Langevin
Grenoble, France
13-14 March 2012

NEUTRONS FOR SCIENCE ®
Institut Laue-Langevin

Tuesday 13 March 2012

K. Zeitelhack: "Detector development based on ^{3}He alternatives"

Session 1: ^{10}B detectors (part 1)

M. Koza: "Guidelines for a time-of-flight spectrometer detector optimized for material science"
J. Lacy: "A large-area, multi-tube neutron imaging detector based on $^{10}B_4C$ coated straws"
M. Klein: "the ^{10}B based Jalousie neutron detector - an alternative for ^{3}He filled position sensitive counter tubes"
J. Correa: "On the efficiency of the $^{10}B_4C$ MultiGrid Neutron Detector"
JF Clergeau: "Study of a MultiGrid prototype for IN6"

Session 2: Coating techniques

Y. Yang: "Boron lined gaseous detector research in Tsinghua University"
P. Chaudhari: "Neutron absorber boron carbide thin films by hot-wire chemical vapor deposition technique"
C. Höglund: "$^{10}B_4C$ thin films for neutron detection"
A. Khaplanov: "Optimization and diagnostics of $^{10}B_4C$ coatings for the MultiGrid detector"
G. Nowak: "Recent progress of magnetron sputtered B4C - converter layers onto Si substrates and A1 detector plates"

Wednesday 14 March 2012

N. Rhodes: "Detector JRA in FP7-2"
R. Hall-Wilton: "Latest news from ESS"

Session 3: ^{10}B detectors (part 2)

A. Menelle: "A Micromegas thermal neutron detector with ^{10}B layers"
I. Stefanescu: "Development of a cathode design for large area neutron detectors based on Boron-10 converters"
F. Piscitelli: "Gamma-ray sensitivity of ^{10}B based MultiGrid detectors"
R. Kampmann: "First tests of Thin Conversion Layers in Inclined Geometry"

Session 4: BF_3 detectors

S. Alimov: "First tests of Linear-Position-Sensitive Twin Tubes with BF_3"
J. Orban/L. Cser: "New development for two dimensional multiwire position sensitive detectors filled with BF_3 at the Budapest Neutron Centre"
S. Desai: "BF_3 Based Position Sensitive Detectors: Performance and Challenges"
B. Guérard: "BF_3 detector development at the ILL"

Detector Options for Baseline TDR Suite

Instrument	^{10}B Thin Films $\perp$	^{10}B Thin Films $\parallel$	Scintillators WLS	Scintillators Anger	^{3}He	Micropattern Rate	Micropattern Resolution
Multi-Purpose Imaging	-	-	-	-	-	o	+
General Purpose Polarised SANS	o	+	-	+	o	+	-
Broad-Band Small-Sample SANS	o	+	-	+	-	+	-
Surface Scattering	o	+	-	+	o	+	-
Horizontal Reflectometer	-	o	-	+	+	o	-
Vertical Reflectometer	-	o	-	+	+	o	-
Thermal Powder Diffractometer	o	+	+	-	-	o	-
Bi-Spectral Powder Diffractometer	o	+	+	-	-	o	-
P-M Powder Diffractometer	o	+	+	-	-	o	-
MS Engineering Diffractometer	o	+	+	-	-	o	-
Extreme Conditions Diffractometer	o	+	+	-	-	o	-
Single Crystal Diffractometer	o	+	+	-	-	o	-
Macromolecular Diffractometer	-	o	o	o	-	+	+
Cold Chopper Spectrometer	+	o	o	-	-	-	-
Bi-Spectral Chopper Spectrometer	+	+	o	-	-	-	-
Thermal Chopper Spectrometer	+	+	+	-	-	-	-
Cold Crystal Analyser Spectrometer	-	o	-	+	+	-	-
Vibrational Spectrometer	-	o	-	o	+	-	-
Backscattering Spectrometer	-	o	-	+	+	-	-
High-Resolution Spin Echo	-	o	-	o	+	+	-
Wide-Angle Spin Echo	-	o	-	o	+	+	-
Fundamental & Particle Physics	-	-	-	-	+	+	+

Preliminary

+ = favoured option
o = option
- = disfavoured option

- Most instruments have "He-3-free" options
- Requirement for He-3 significantly reduced
- An array of technologies will be used
- dependent upon a wide range of sources for detectors

(I am now going to take a very biased diversion on the detector technology ESS is concentrating on developments internally)

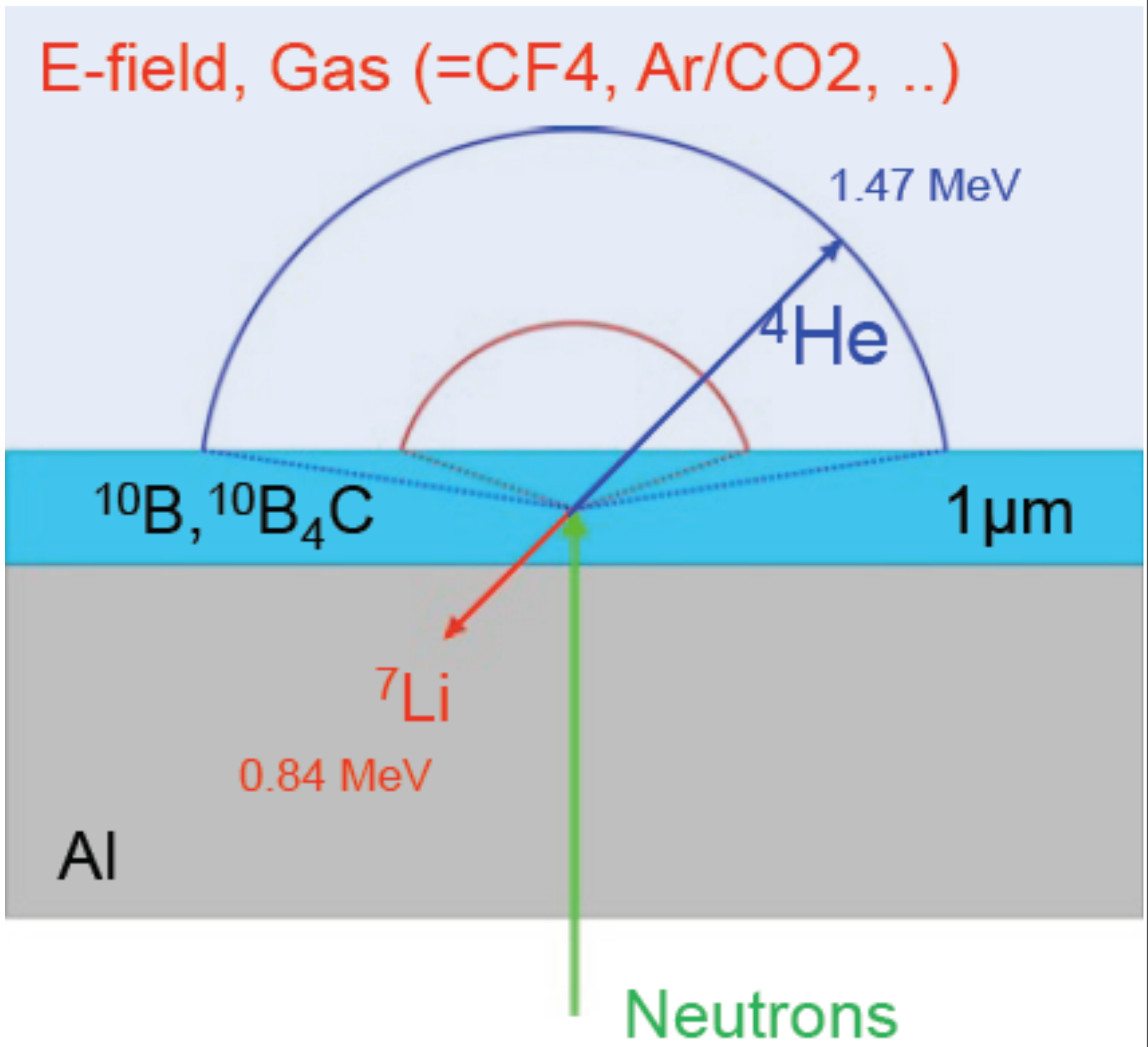
No time to deal with other developments, including several in-kind from German groups (HZB, FZJ, HZG, TUM-FRMII)

Boron-10 Thin Film Detectors

The Boron-10 Detector Principle

- ^{10}B has a neutron absorption of 70% compared to ^{3}He at $\lambda = 1.8$ Å
- ^{nat}B contains
  80 at.% ^{11}B and
  20 at.% ^{10}B
- $^{10}B + n \rightarrow {}^{7}Li + \alpha + 2.3$ MeV

•charged products emitted back to back
•only 1 enters gas volume
•anode wire / electric field to amplify
•collect signal from ionisation process (anode and/or cathode)



Thin precise coatings of Boron Carbide with good adhesion are the key ingredient

10-Boron Carbide Thin Films for Neutron Detection

DC magnetron sputtering: ${}^{nat}B_4C$, ${}^{10}B_4C$

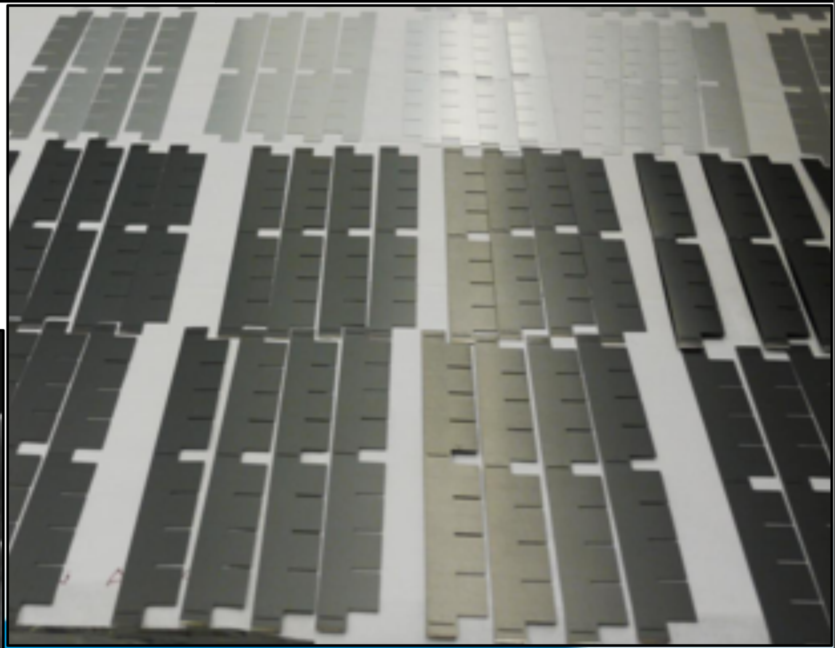
- 2-side coated substrates
- Good adhesion on Al, Si, etc.
- High density, Minimal impurities
- Thickness control and uniformity
- Large area depositions
- Patent application

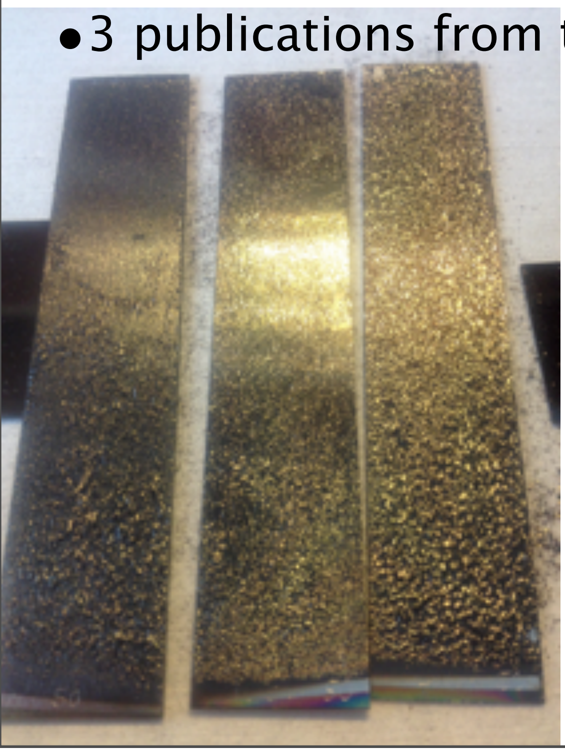
C. Höglund, et. al., J. Appl. Phys. **111**, 104908 (2012)

Spinout about to be setup

- Many attempts by other groups failed
- Boron Carbide has high internal stress
- Key ingredient here: experience!
- Expertise of Linkoping thin film group
- 3 publications from this collaboration

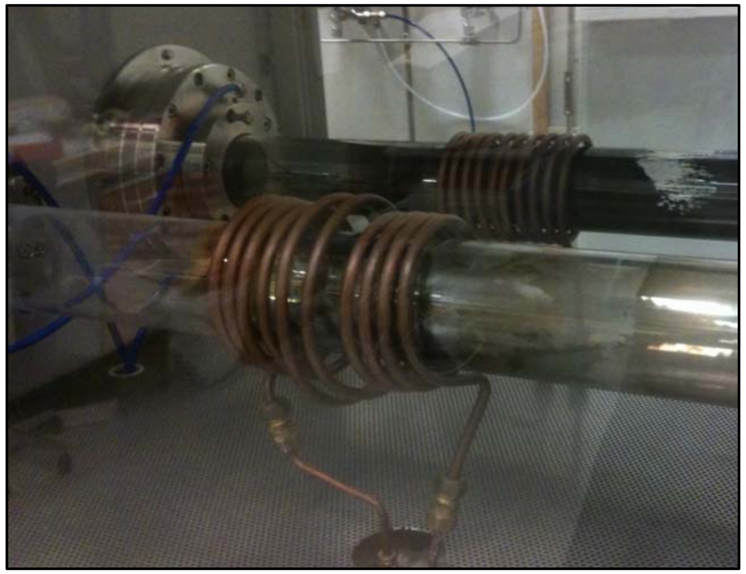
ESS – Linkoping U collaboration

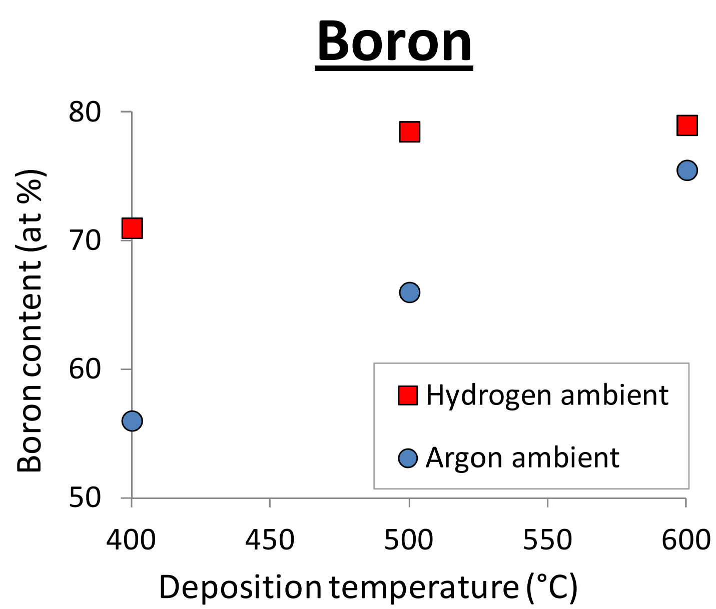


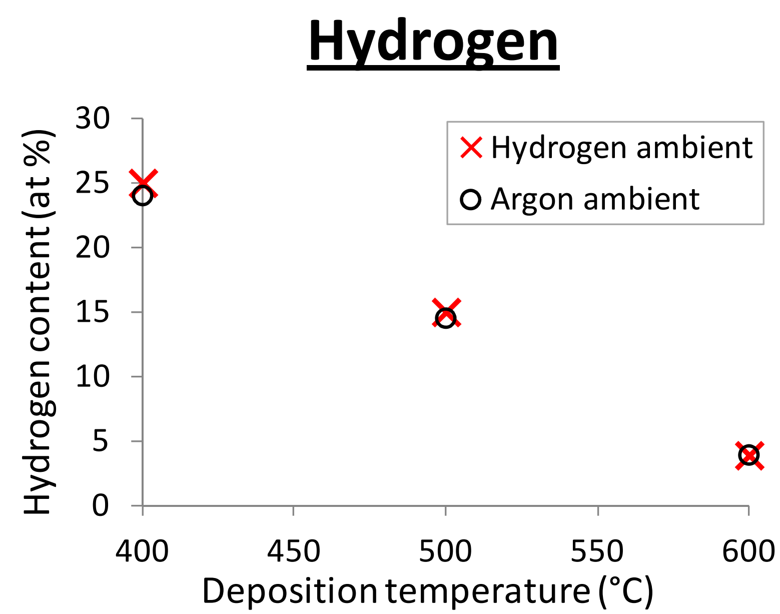


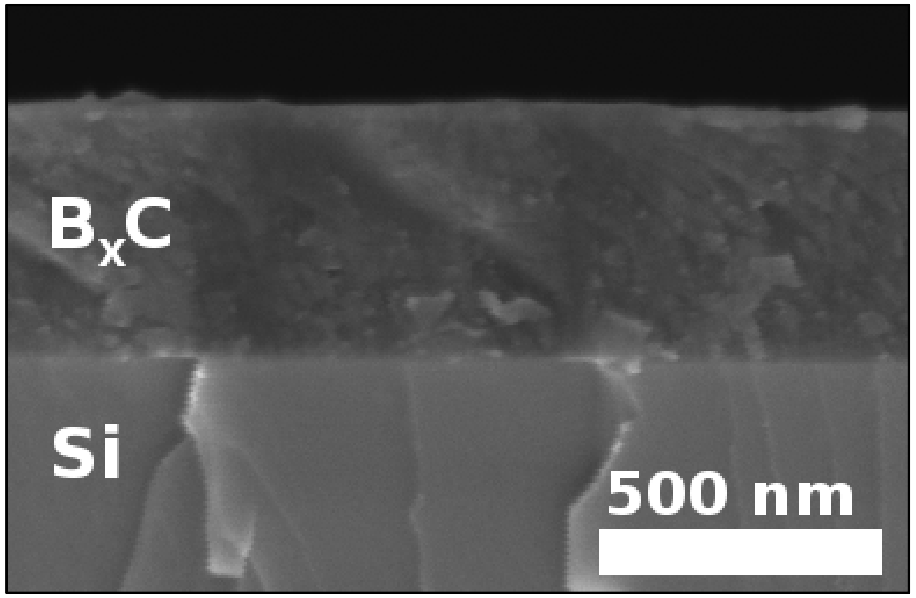
~3 μm ${}^{10}B_4C$

Thermally activated CVD









High quality B_4C films can be deposited by simple, thermally activated CVD at 600 °C using the organoborane TEB as single precursor

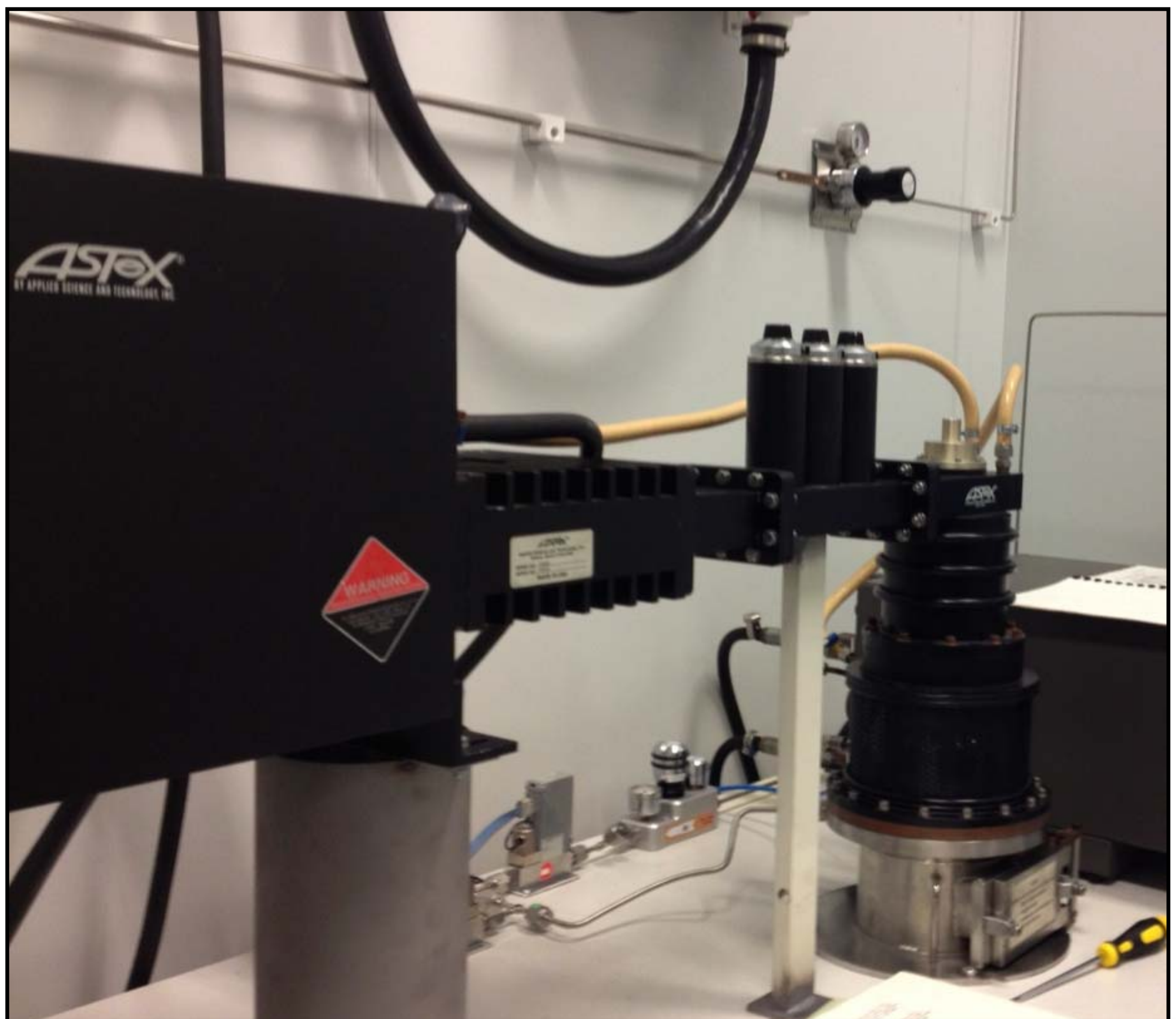
Hydrogen and Boron contents are highly temperature dependent

600 °C yields less than 5 at.% H and close to bulk density!

H. Pedersen, C. Höglund, et. al., Chem. Vap. Deposition **18**, 221

Plasma assisted CVD

- Henrik Pedersen (LiU)
- Mewlude Imam (new student, ESS-LiU)
- ESS



Develop a working low temperature CVD process for $^{10}B_4C$

Linkoping - ESS - ILL Collaboration on B-10 Thin Films Detectors

Linköpings universitet
INSTITUTE OF TECHNOLOGY

Jens Birch
Lars Hultman
Jens Jensen

EUROPEAN SPALLATION SOURCE

Carina Höglund*
Anton Khaplanov**
Richard Hall-Wilton
Kalliopi Kanaki
Thomas Kittelmann
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NEUTRONS FOR SCIENCE®

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CRISP

Linköpings universitet INSTITUTE OF TECHNOLOGY — ILL NEUTRONS FOR SCIENCE — ess EUROPEAN SPALLATION SOURCE

Large Prototype '2' for Boron-10 Thin Films Detectors - Summer 2011

ESS Activity Report

ILL Bulletin

And it works! Signs of success for a new boron-layer detector

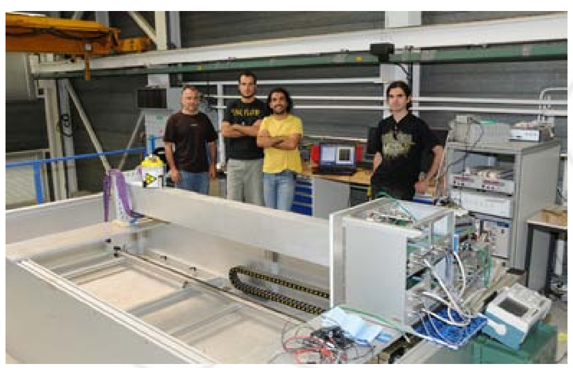
A prototype boron-layer detector has been undergoing initial testing with an AmBe source in the SDN lab. It has a detection surface of 8cm x 200cm and the neutrons are captured by 30 layers of 10B4C, each a micron thick.

The energizing signal produced by the capture is amplified by proportional counters, and these also supply one of the position coordinates. The other coordinate is provided by reading the signal in the segmented cathode. We have baptised the detector a "multi-grid detector" and it was patented in 2010.

The prototype has yielded encouraging results in terms of measurement efficiency and this has raised hopes for the next phase, the production of a module similar in size to those on IN5, vacuum-compatible. The technique has been developed in collaboration with the ESS and is destined to replace current 3He-based technology.

Bruno Guérard

From left to right: Jean-Claude Buffet, Francesco Piscitelli, Jonathan Correa of the ILL, and Anton Khaplanov from ESS.



De gauche à droite: Jean-Claude Buffet, Francesco Piscitelli, Jonathan Correa from the ILL, and Anton Khaplanov from ESS

Ca marche ! Premier succès du prototype de détecteur à couches de bore

Le prototype de détecteur à couches de Bore a été testé avec succès au laboratoire du SDN, durant les premiers tests avec une source américium-beryllium(AmBe).

La surface de détection est de 8 cm x 200 cm; la capture des neutrons est assurée par 30 couches de 10B4C, d'épaisseur 1 micron chacune; le signal de charge produit par cette capture est amplifié par des compteurs proportionnels, qui fournissent en même temps l'une des coordonnées de position; l'autre coordonnée est donnée par la lecture de la cathode segmentée. Le principe de ce détecteur appelé Multi-grille a été breveté en 2010.

Les bons résultats obtenus avec ce prototype en mesure d'efficacité permettent d'envisager avec une certaine confiance la phase suivante, qui consiste à produire un module de même taille que ceux d'IN5, compatible avec le vide. Cette technique développée en collaboration avec ESS a pour but de remplacer la technique actuelle à base d'3He.

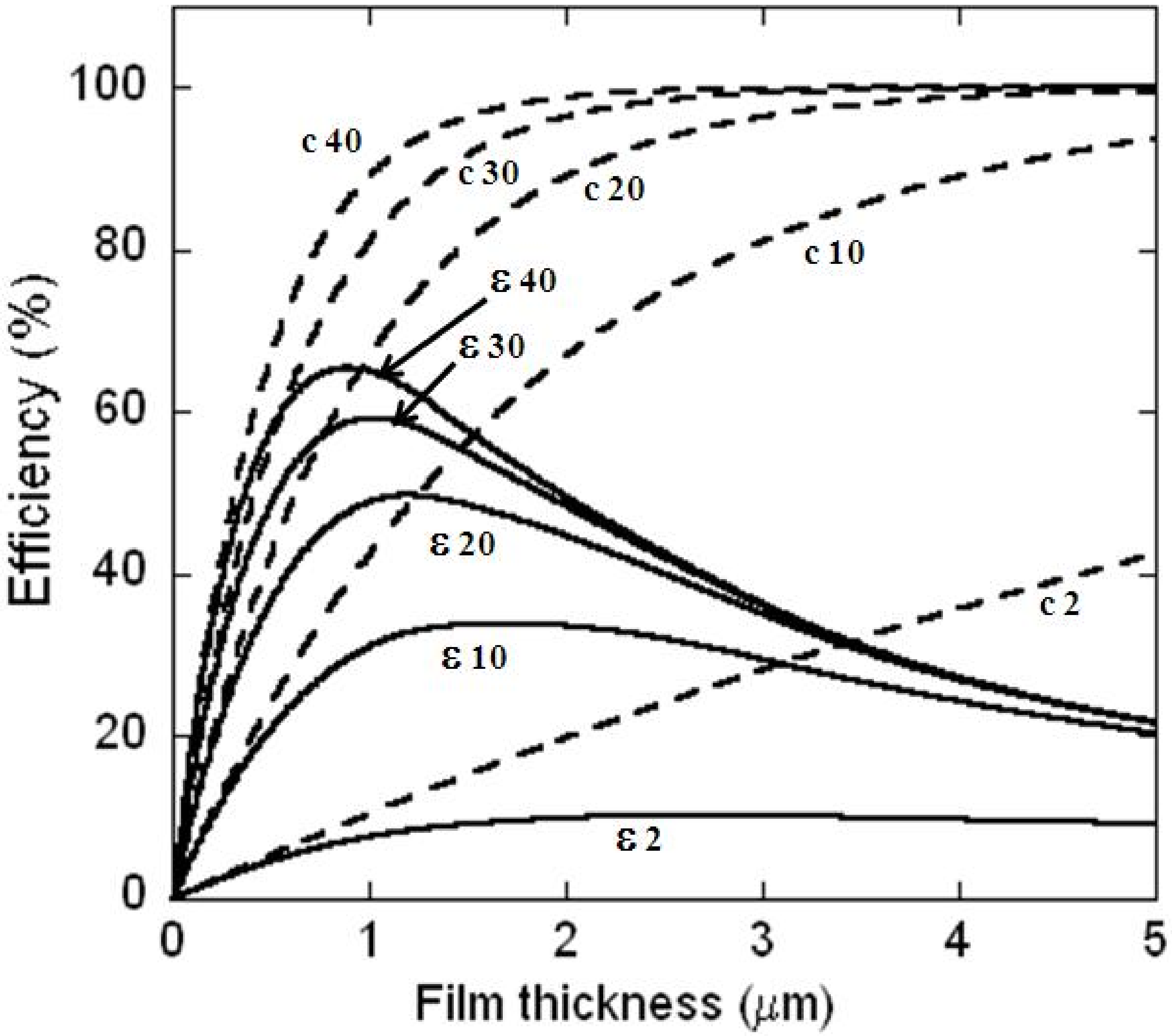
A detector success story

Helium-3 has been the material of choice for large-area detectors used in neutron experiments. However, this isotope is now in short supply, so alternative detector gases are needed. In June 2010, the ESS detector group, in collaboration with the ILL and Linköping University in Sweden, started the development of detectors exploiting thin films of boron-10. Preparing chemically stable thin films that will have areas of many square metres is extremely challenging. Nevertheless, the first prototype has been assembled and tested at the ILL where it performed to specification. Work is ongoing on a second prototype (2m x 10cm active area) to be tested in the summer of 2011. To this end, thin films of boron-10 have been deposited on 6 square metres of sheet aluminium. The aim is to use the results to design a full-scale demonstrator detector in 2012.

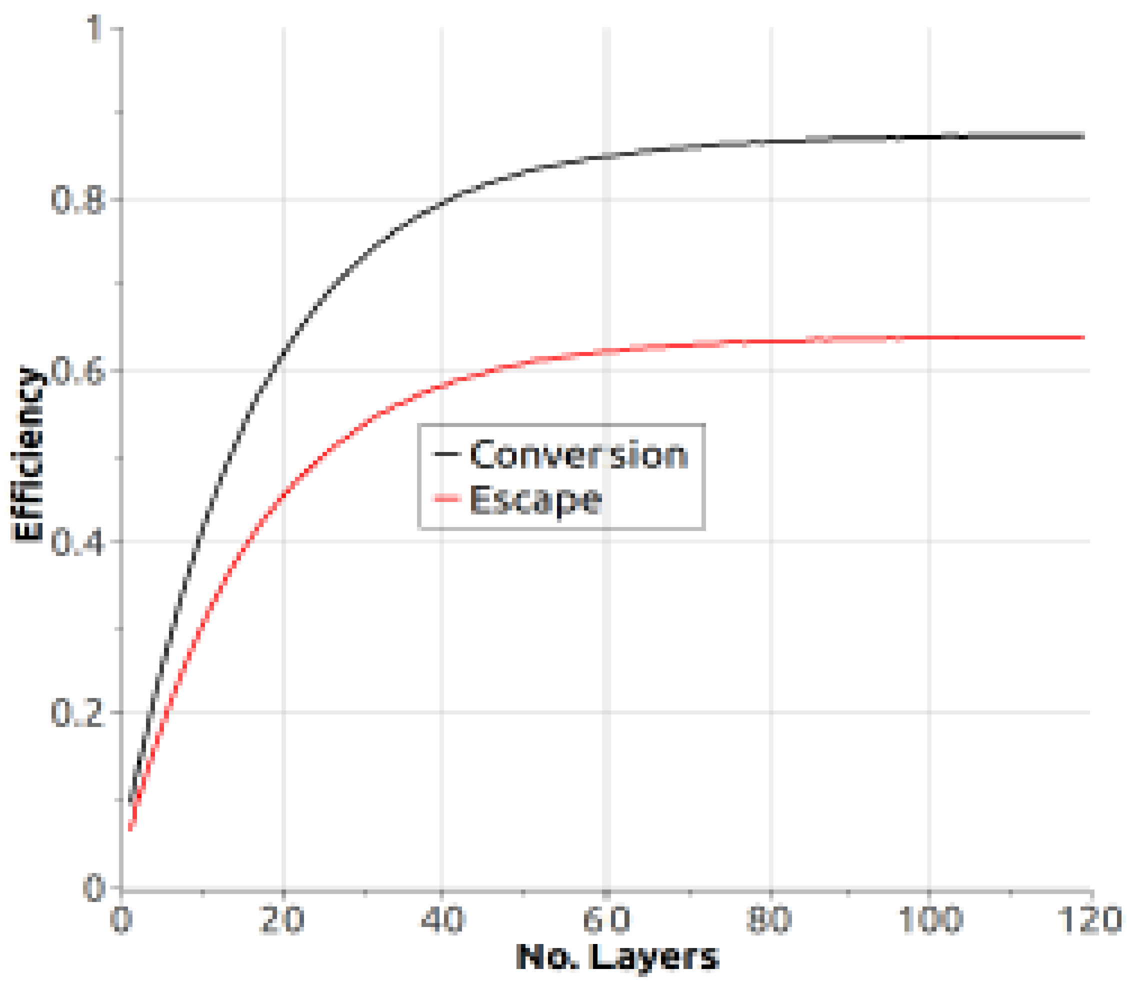
Ideal absorption. The absorption profile of the neutrons with depth inside the detector from the initial prototype tested at the ILL. The measured profile agrees very well with the ideal calculated profile.

Illustration: European Spallation Source
Idea: Marianne Ekdahl, Photos: Jens Birch, Text: Nina Hall, Graph: Richard Hall-Wilton, Graphic design: Christina Hoff

MC simulation (2.5 Å neutron wavelength)



Efficiency vs thickness
(interaction with Aluminium substrates is NOT taken into account)



Efficiency vs number of layer (1 μm thick)

Complicated optimisation needed - many layer detector

What might a Cold Chopper Spectrometer look like for ESS?

Let's try and make a guess:

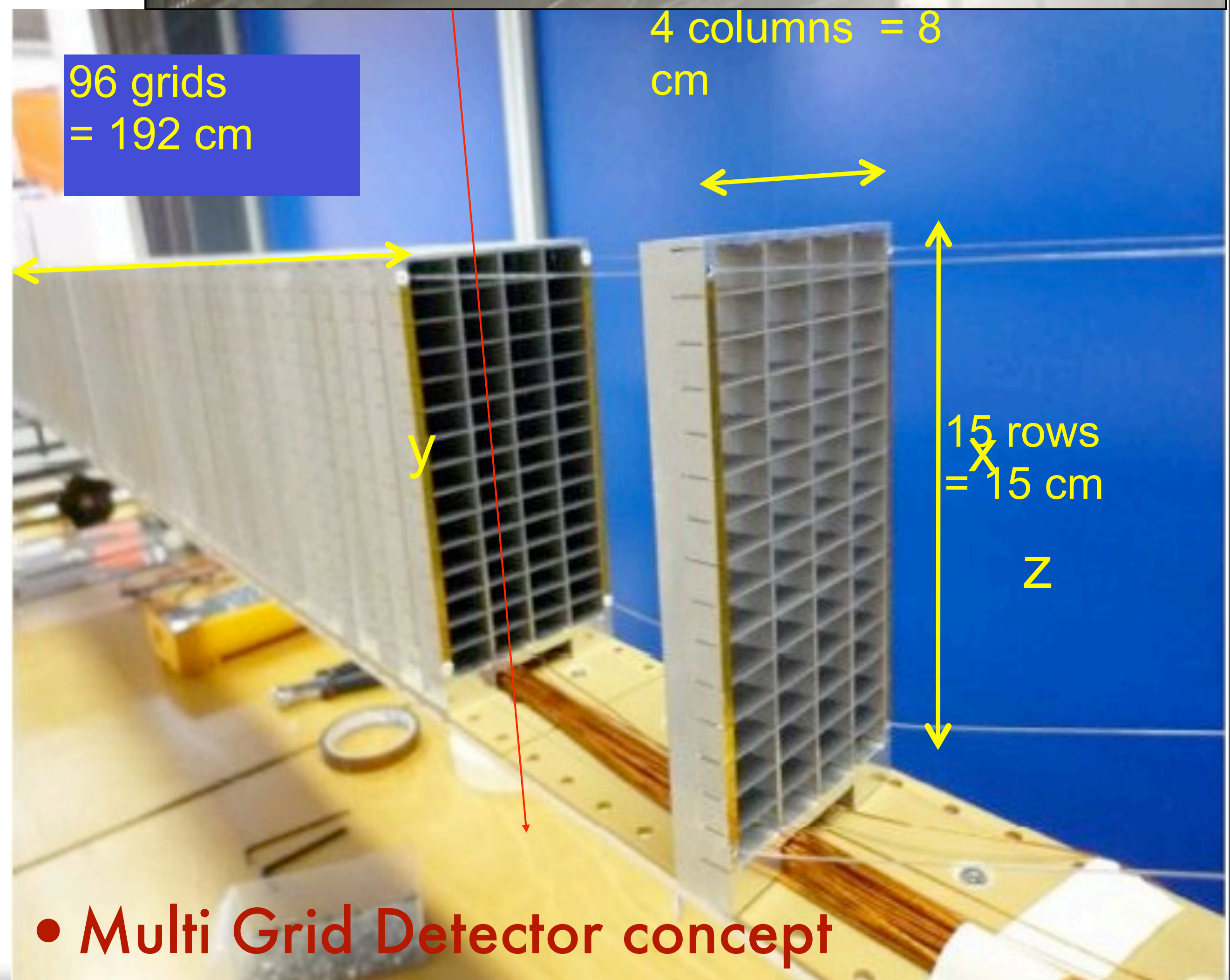
- Reference instrument suite has 80m^2 active area
- Position resolution: 1cm
- Say: 4m height x 20m circumference
- Lets assume here that this is a day 1 instrument

Pixels and Readout Channels:

- x: 2000 pixels
- y: 400 pixels
- z: 15 pixels
- Total: 12 Mpixel

- In terms of readout channels, this implies:
  - Grids/Cathodes: 200 stacks, 200 grids = 40k
  - Anodes: 200 stacks, 150 anode wires = 30k
  - Total: 70 k readout channels

Needs to be as cheap as possible



Outlook for a Cold Chopper Spectrometer for ESS...?

- 2010: Conceptual prototype - “P1”
- 2011: 2 x 0,1m = 0.2 m^2 prototype
- 2012:
    - “Proto 1.1”
    - Build demonstrator for test at ILL on IN6 (if approved): demonstrate “real” performance side-by-side with He-3
    - With feedback from above, design possible full scale demonstrator for IN5 (2.4x0.8m = 2.4 m^2)

- 2013:
    - Build and test the full scale demonstrator of IN5-like module dimensions as part of the CRISP FP7 programme
    - Design a prototype module for ESS large area detectors (chopper spectrometers ...), **including appropriate first prototype electronics and DAQ systems - several m^2?**

- 2014:
    - Build and test full scale ESS prototype large area module (2-4 m^2)

Construction:

- 2015:
    - Ready to start construction for a large chopper spectrometer ... ?

- 2015-2018:
    - Production of 10B4C thin films (4 years expected)
    - Detector assembly
    - **Electronics and data acquisition really needs to be finalised latest in 2016**

- 2019:
    - Installation and neutrons ...?

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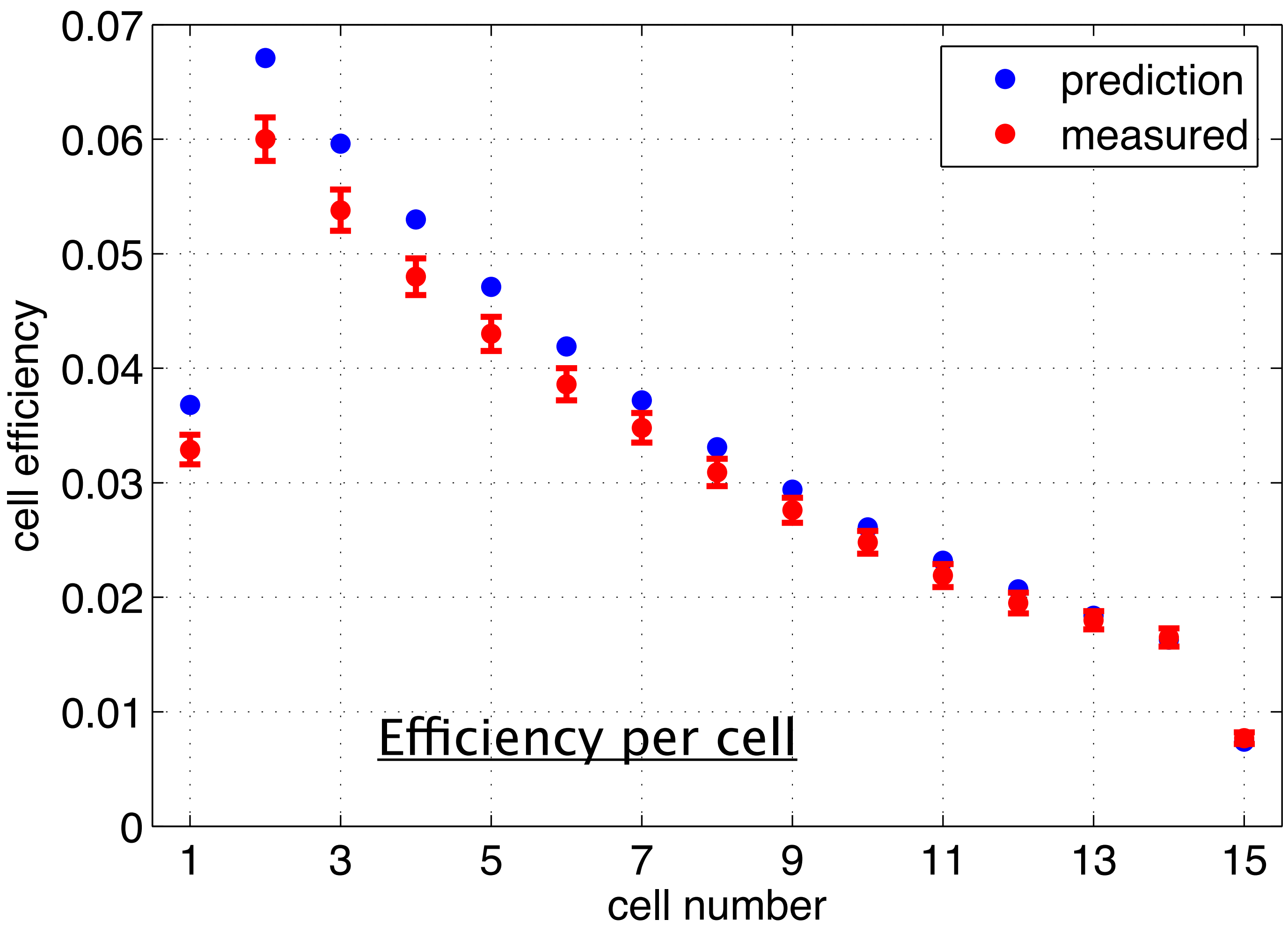
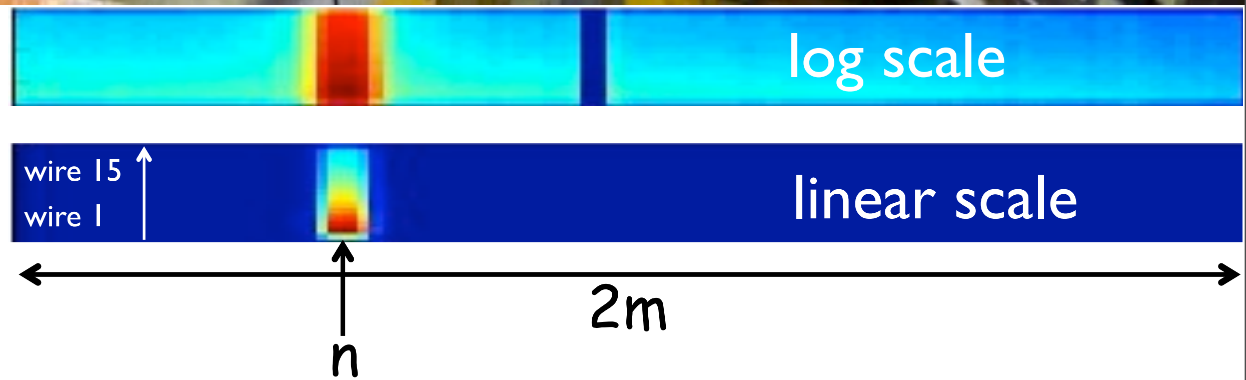
Results from tests with beam of Prototype ‘2’

- Each cell performs as predicted
- ~50% detection efficiency for 2.5 Å neutrons

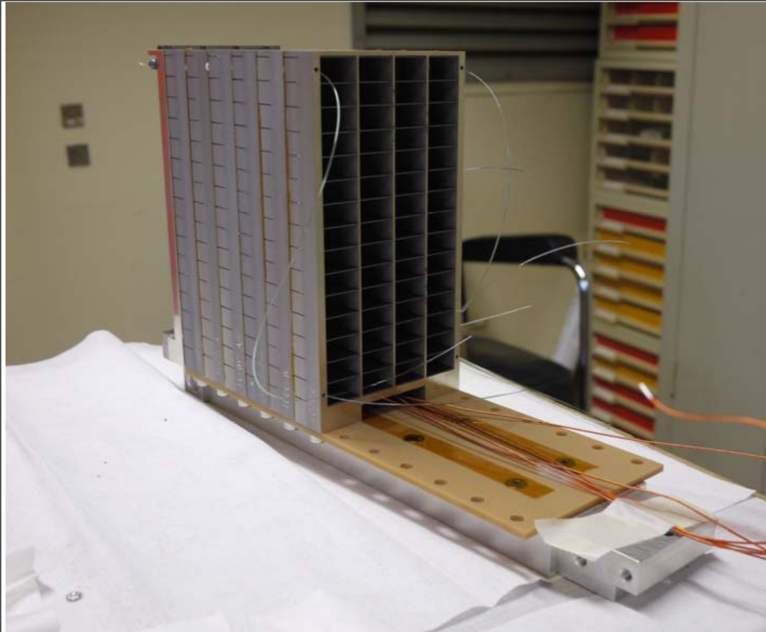


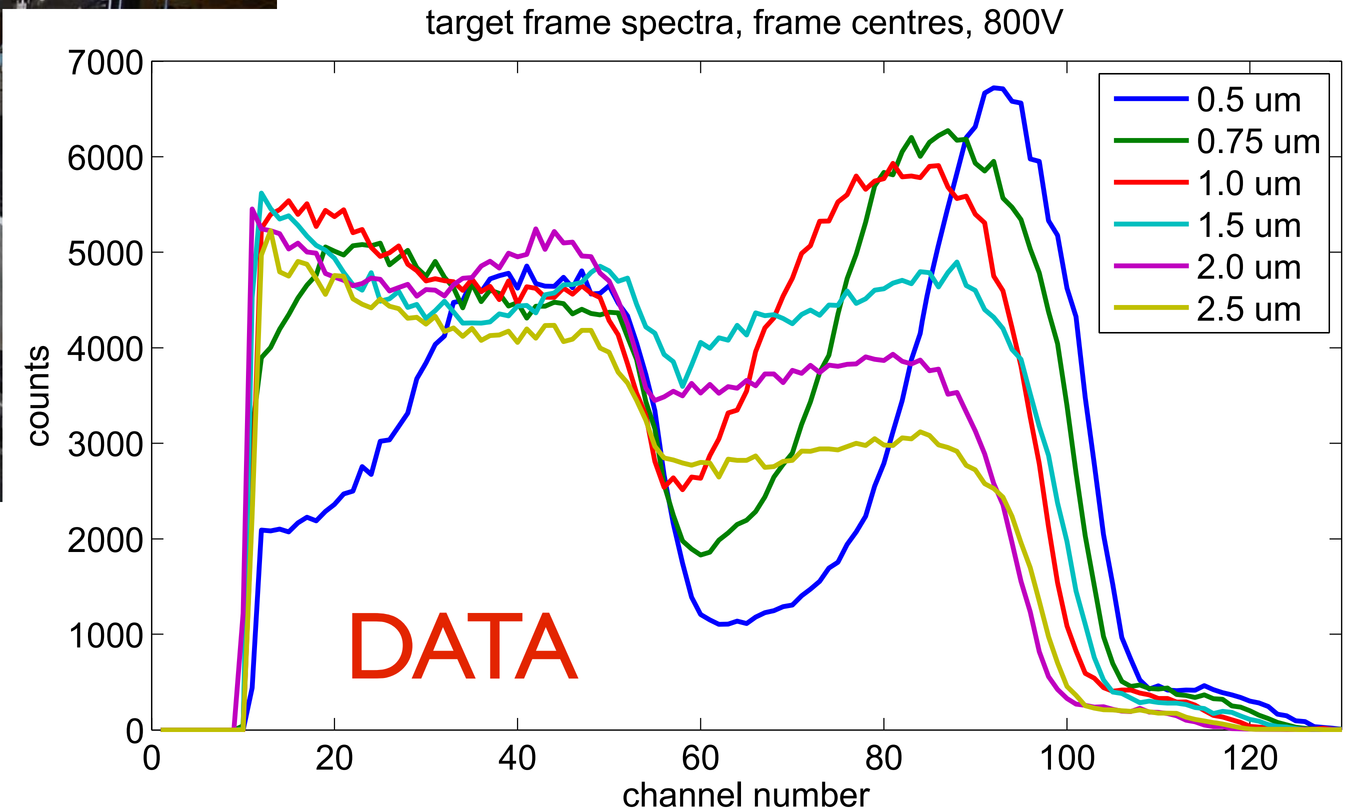


$^{10}B_4C$-based multi-grid detector feasible

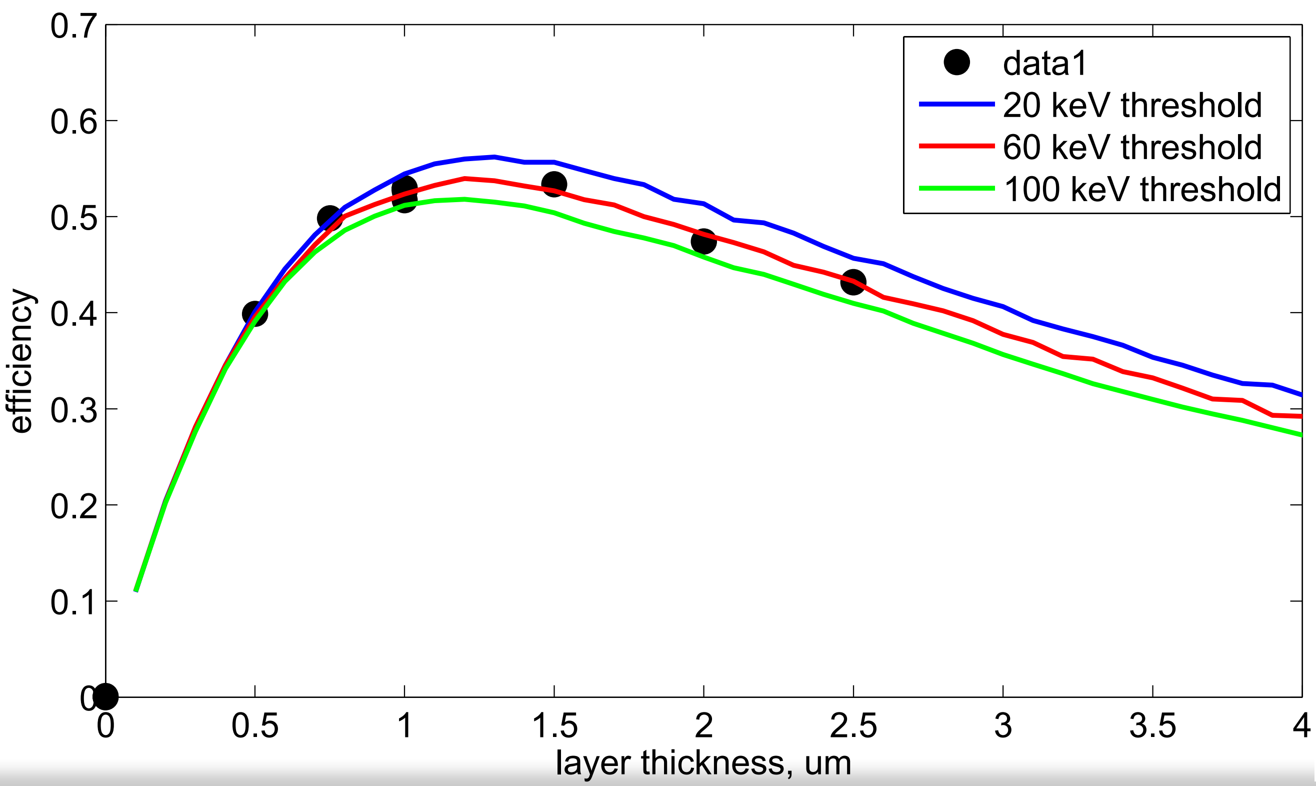
B, Geraud et al., subm. NIM A (2011).
A. Khaplanov, K. Andersen, R. Hall-Wilton et al., Proc. of ICANS XX, Bariloche, Rio Negro, Argentina, 2012.
J. Correa et al., subm. TNS (2012)
J. Correa, PhD Thesis (2012)

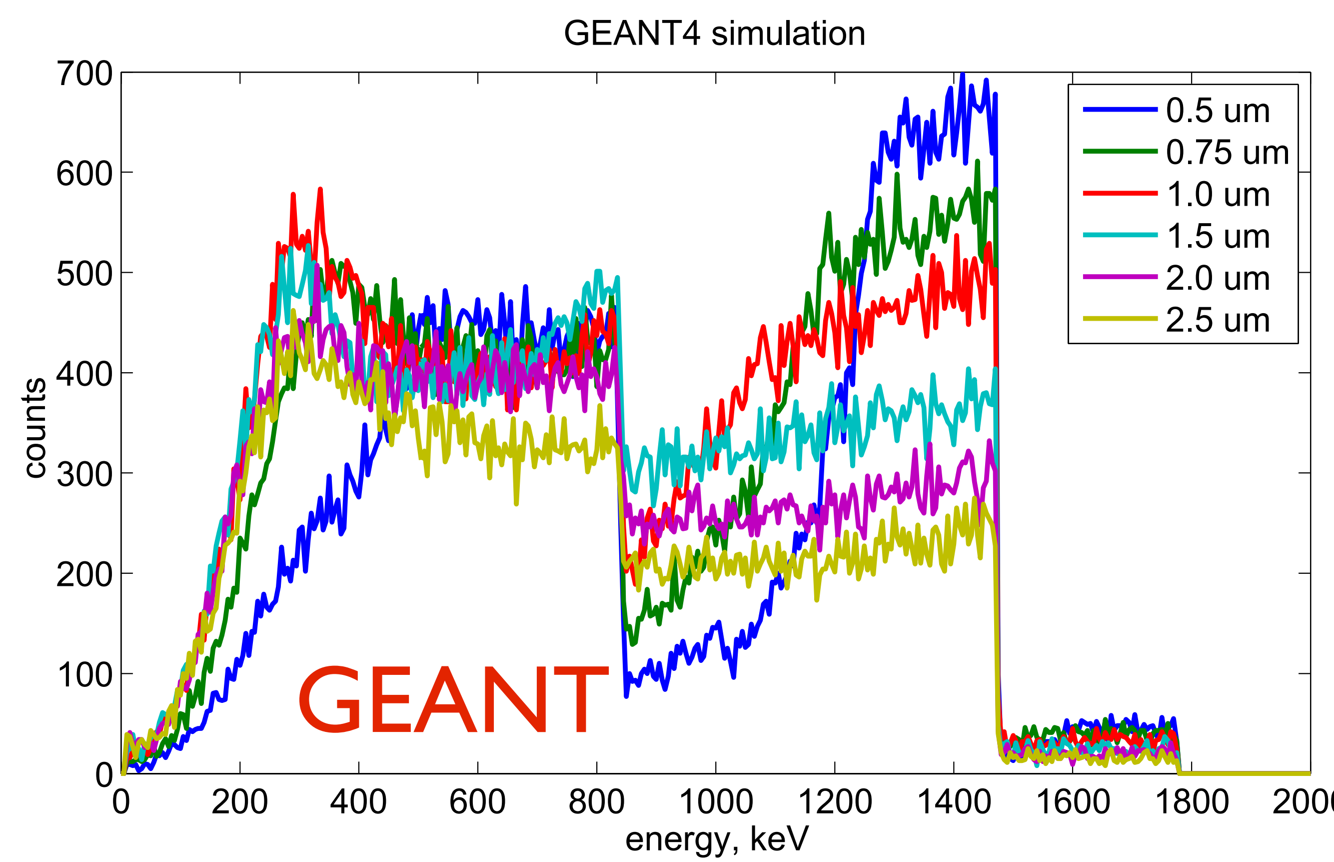
P1.1 - 2x20cm (2012)



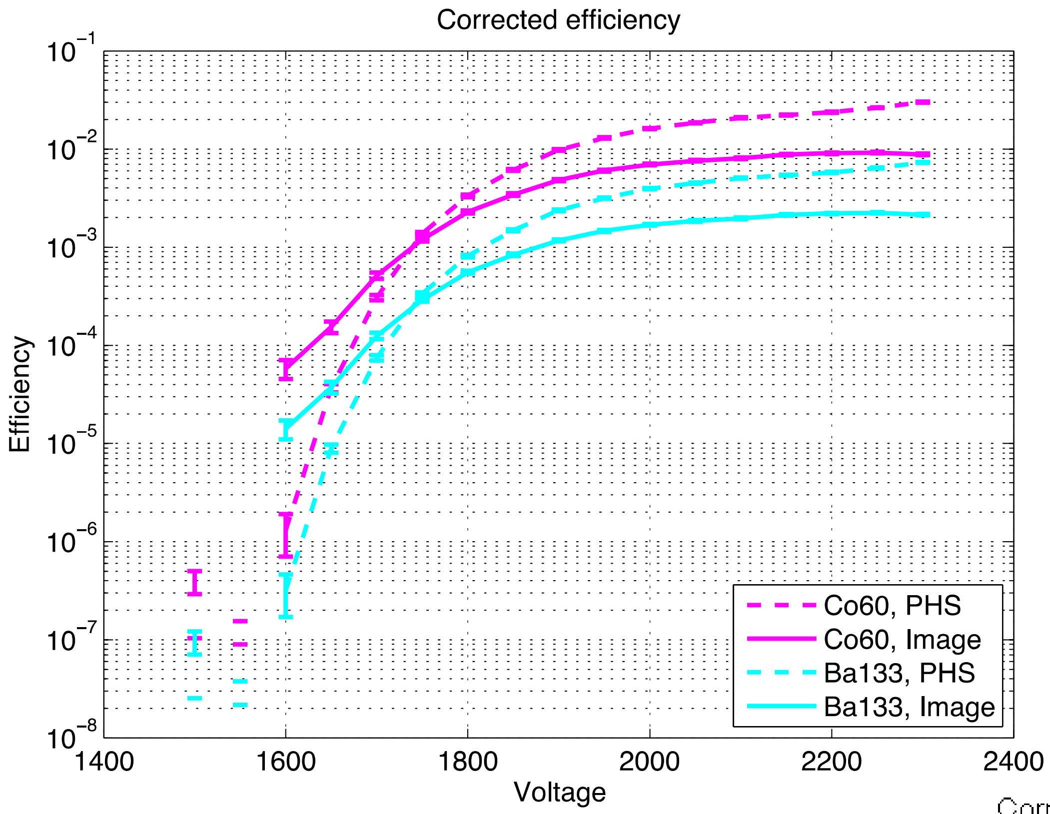


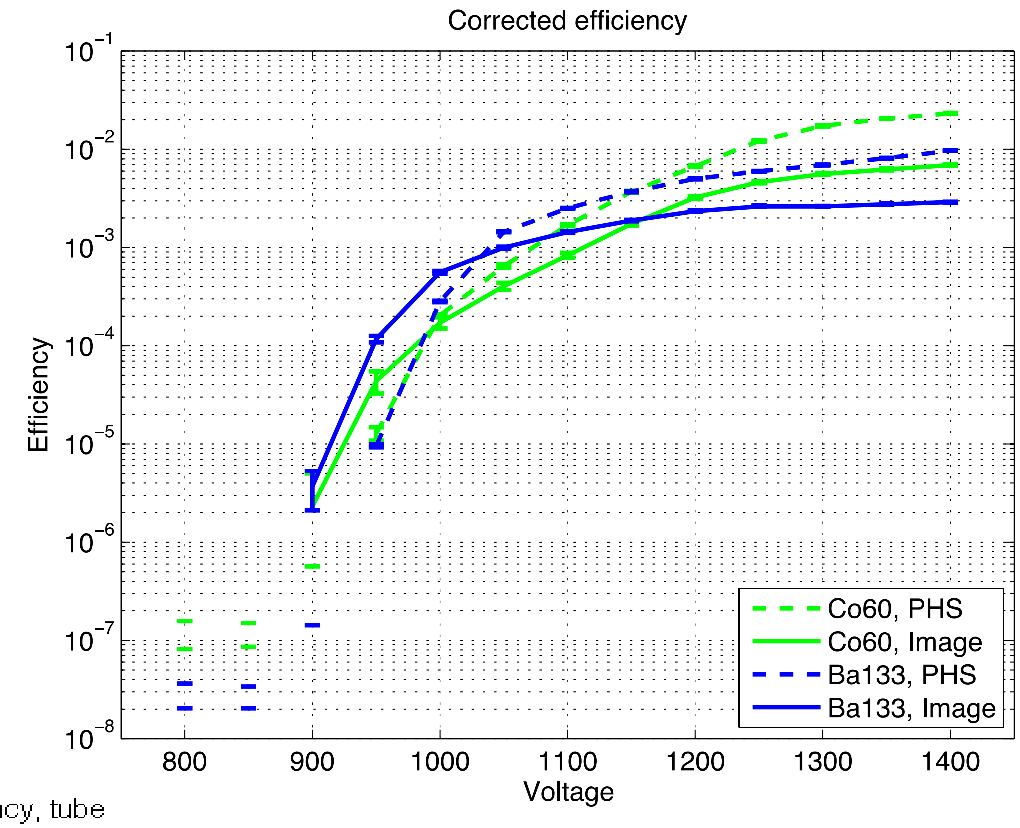
- Efficiency and pulse-height spectra understood as function of layer thickness



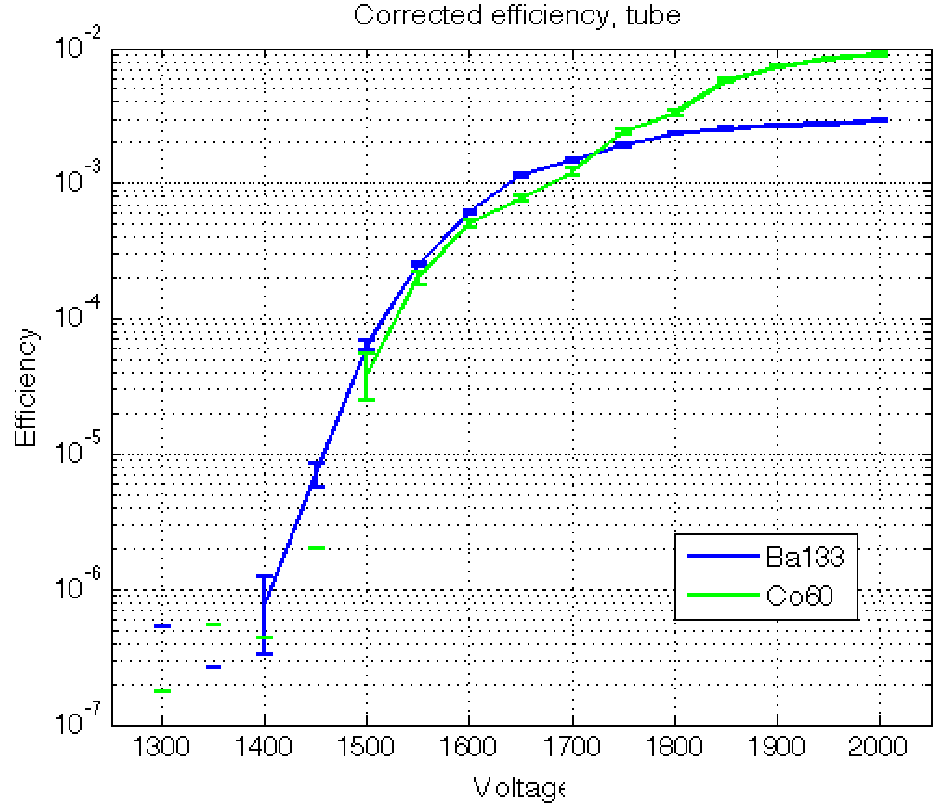


Gamma efficiency, P11, He3





P11, CF4

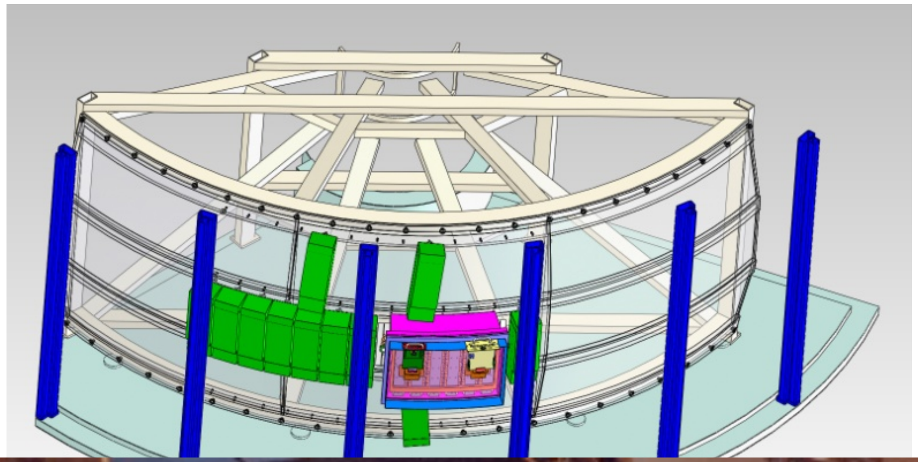


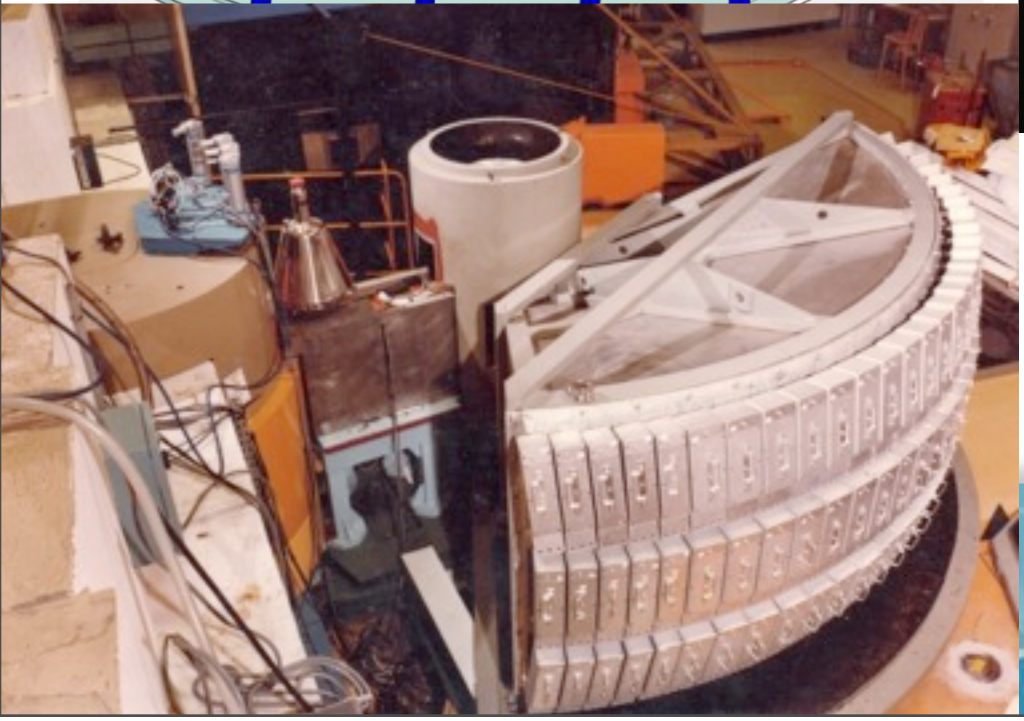
P11, ArCO2

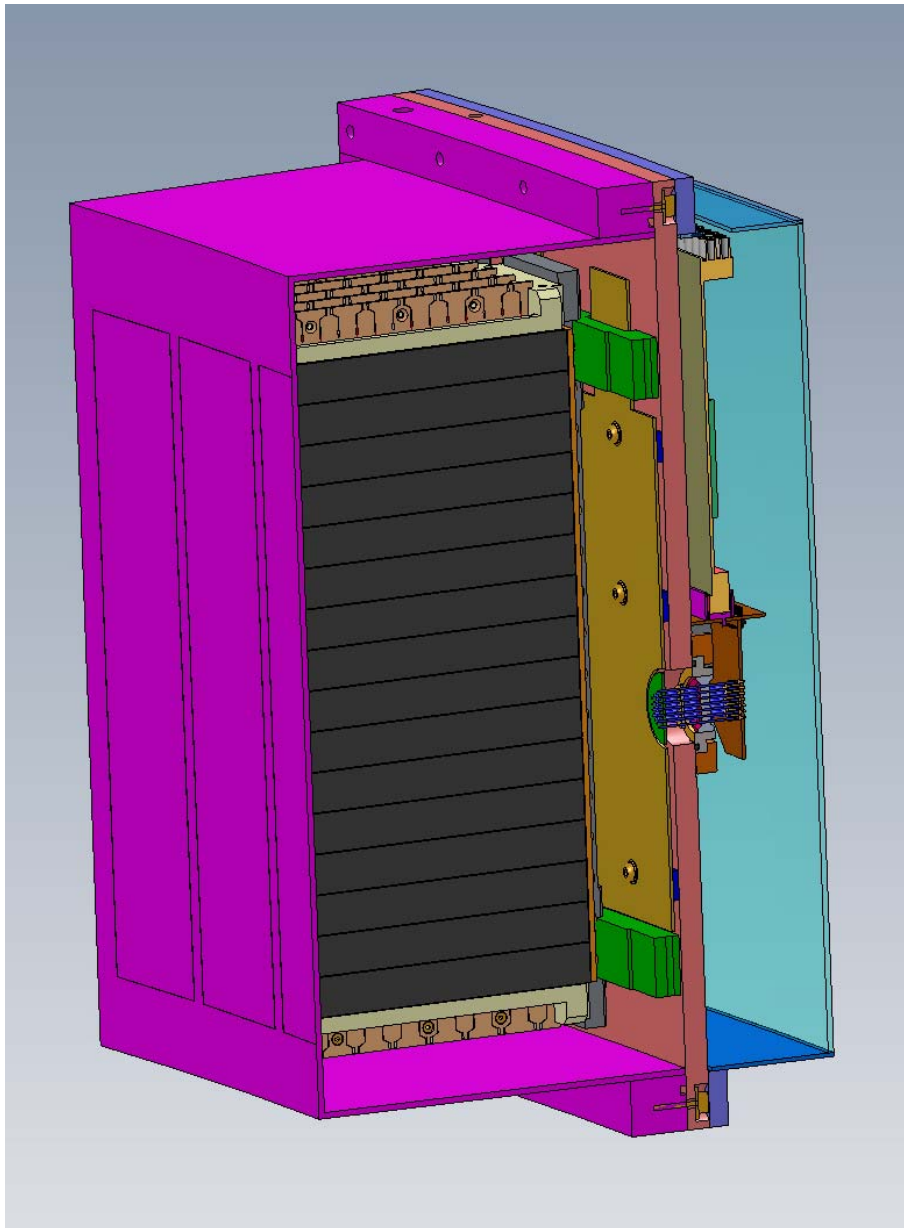
Hexagonal He3

- gamma rejection as good as He-3 possible
- part of optimisation process efficiency vs gamma efficiency

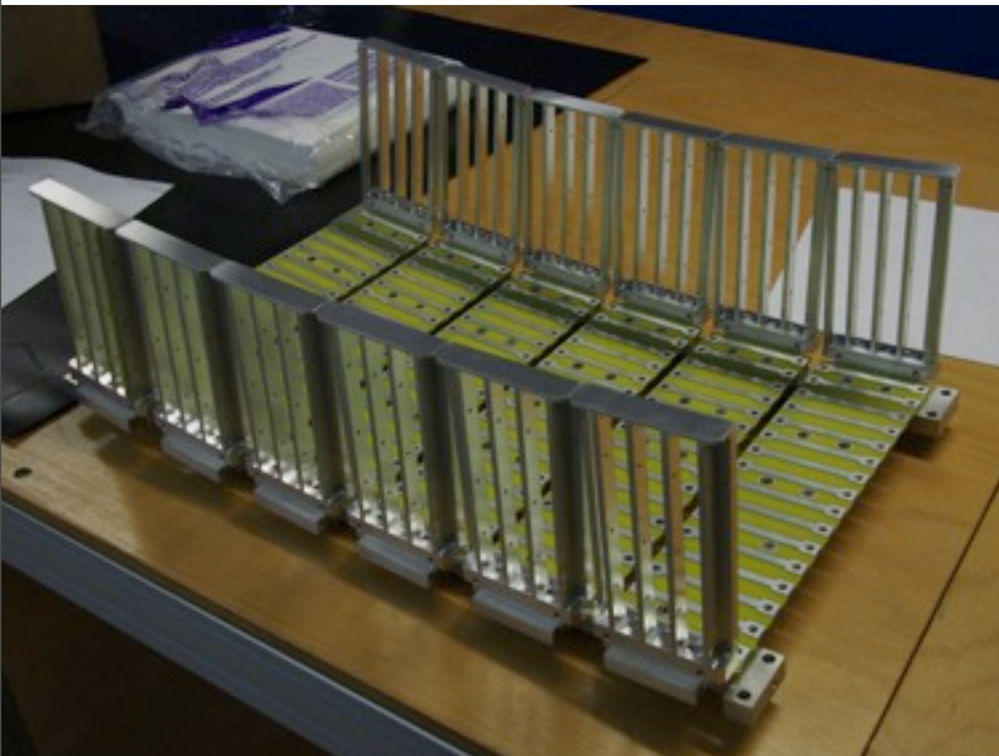
Test of a Multigrid prototype on the IN6 TOF spectrometer

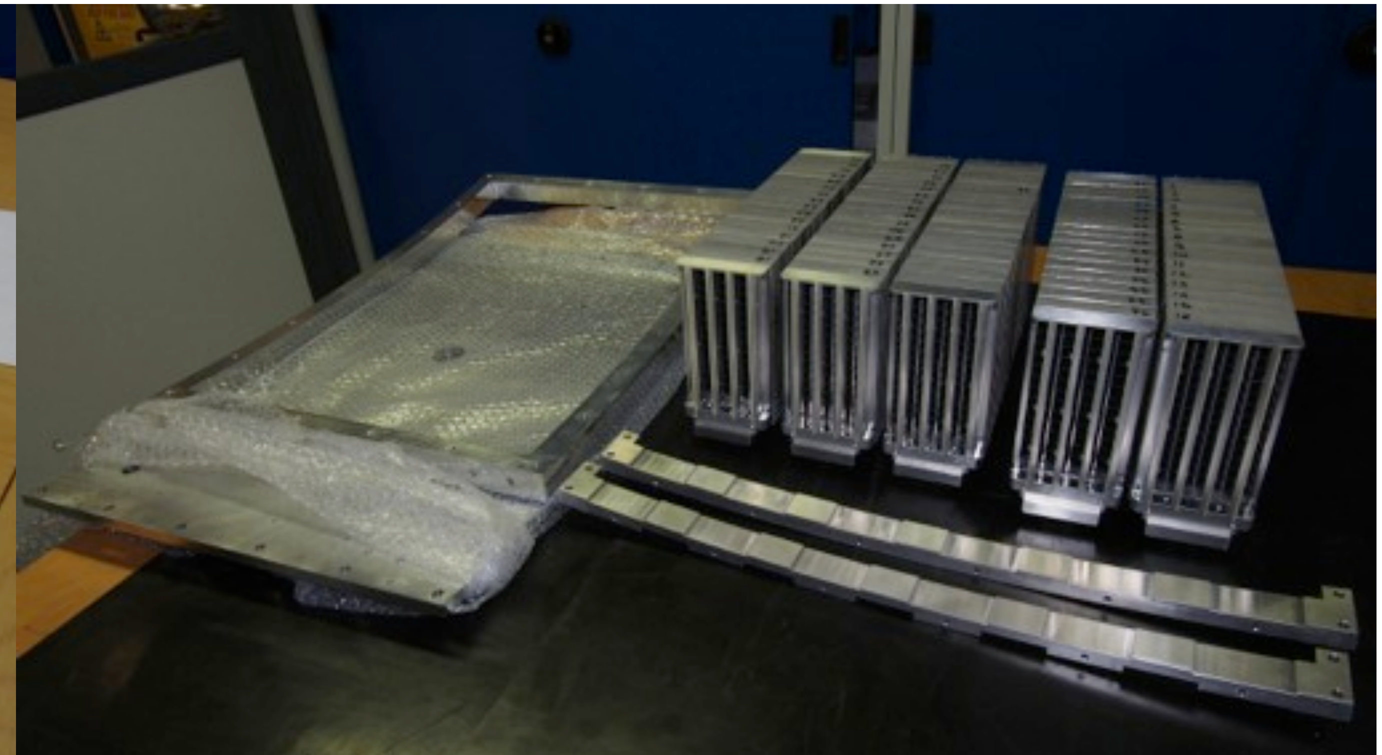


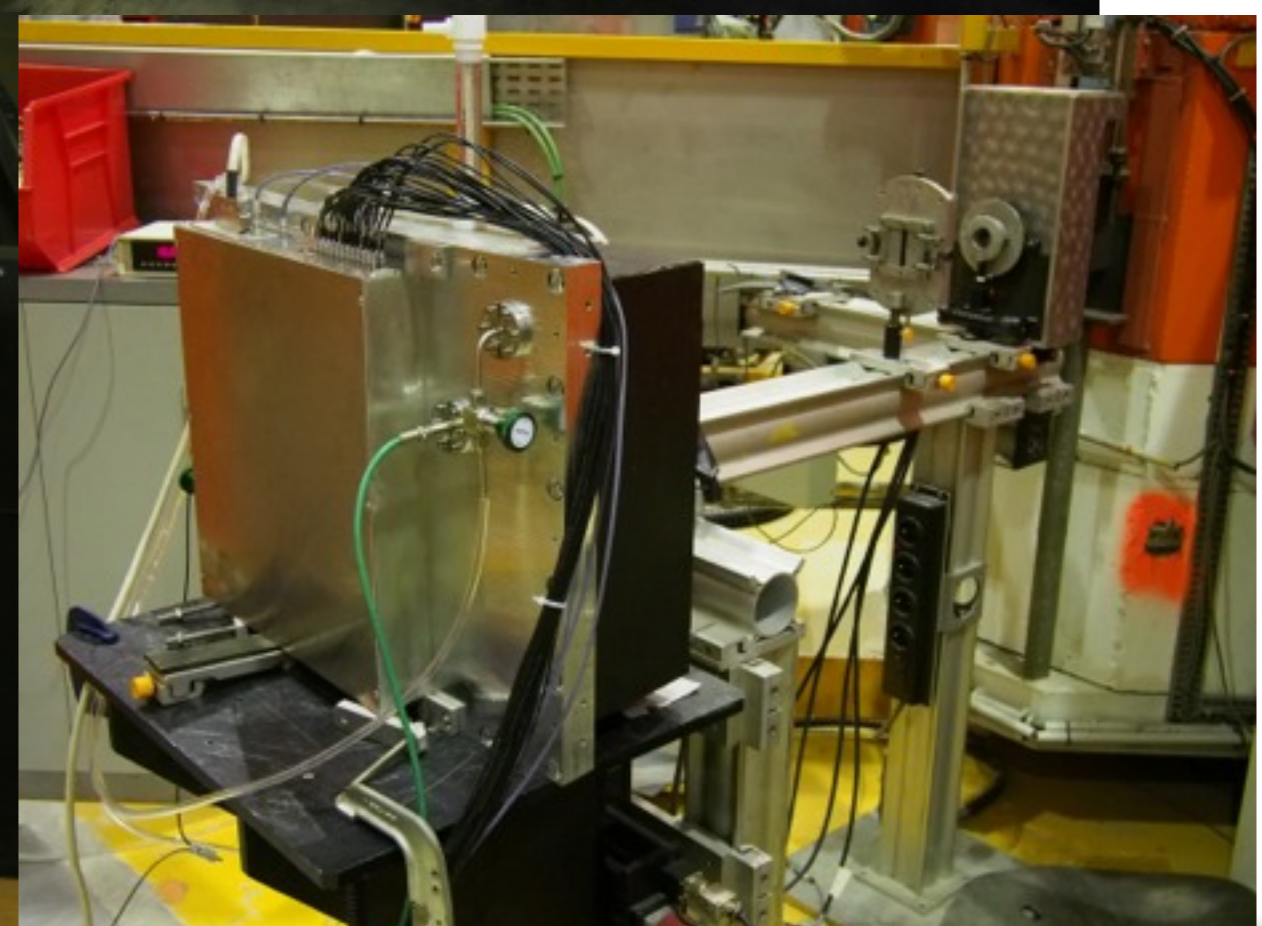




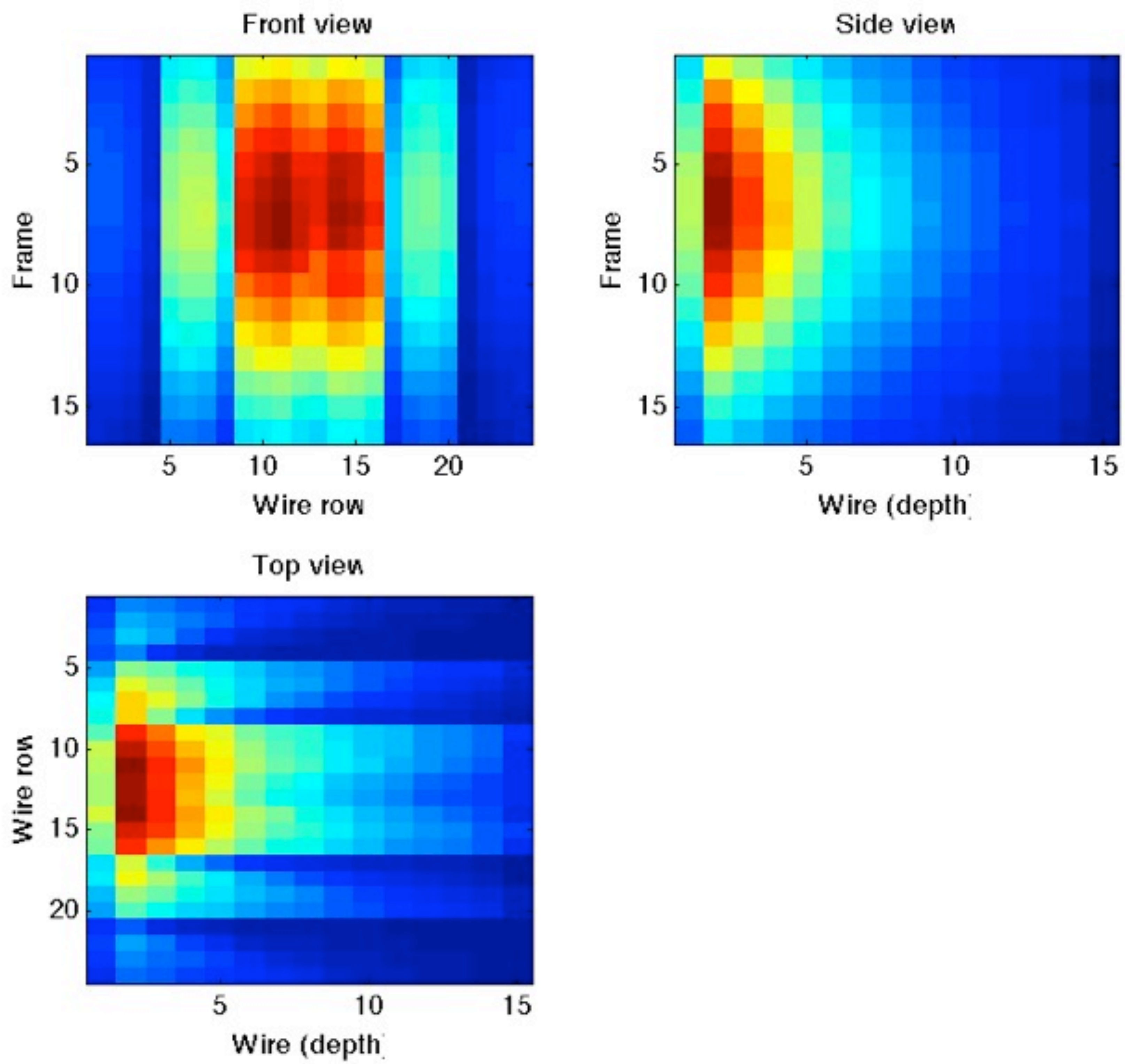
IN6 Demonstrator



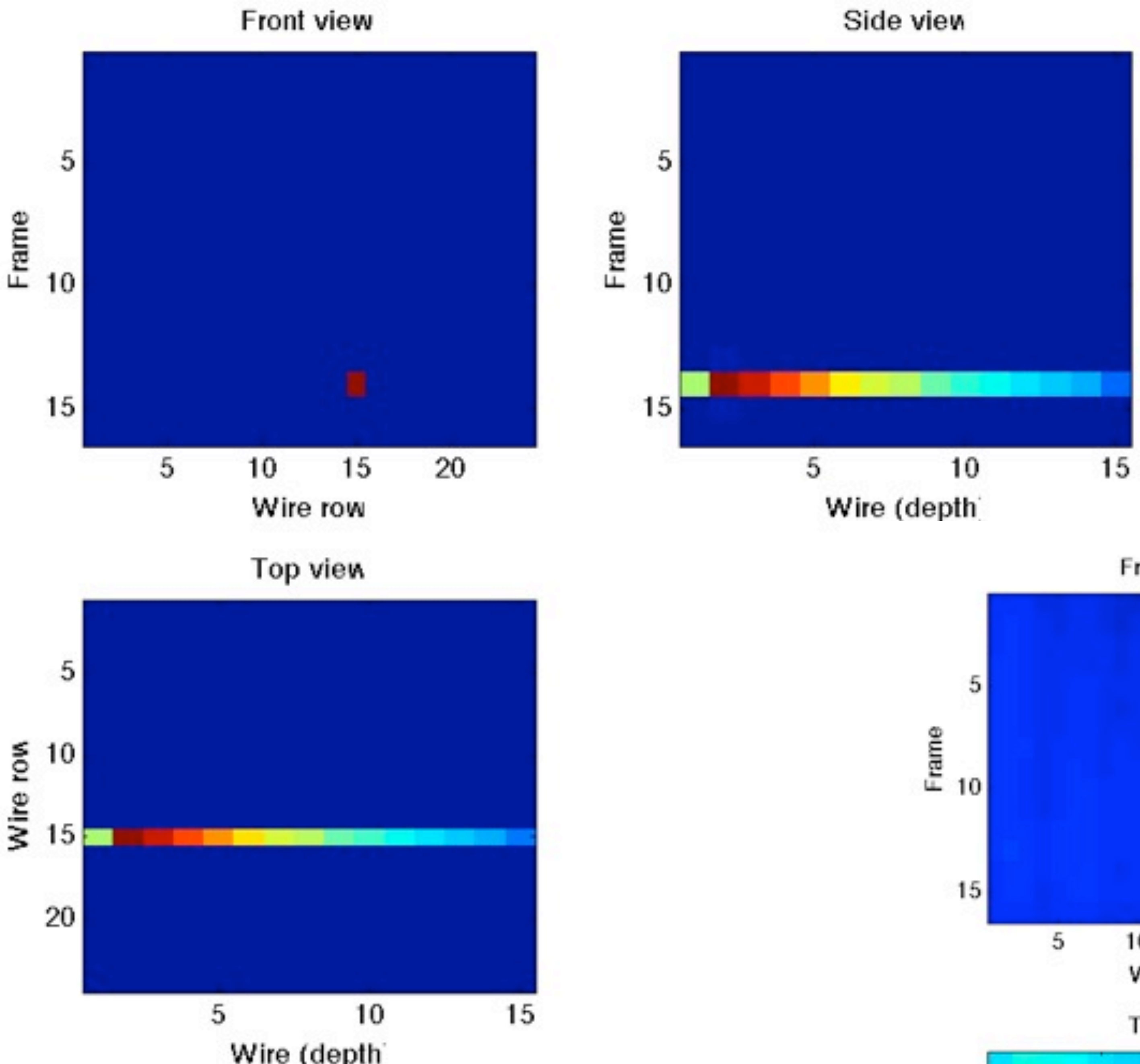




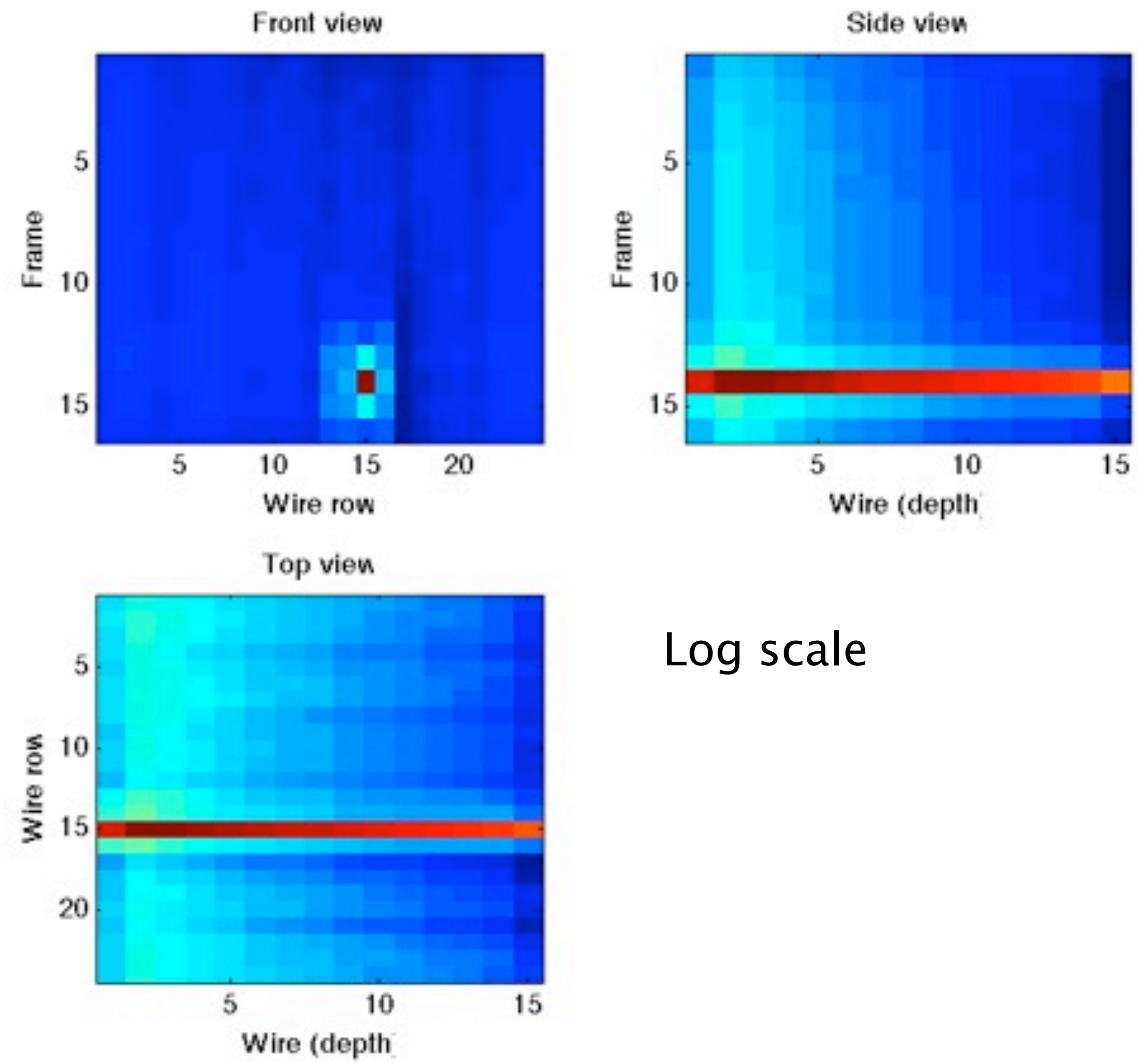
IN6 Prototype - Am/Be Source Image



IN6 Prototype - Beam Image

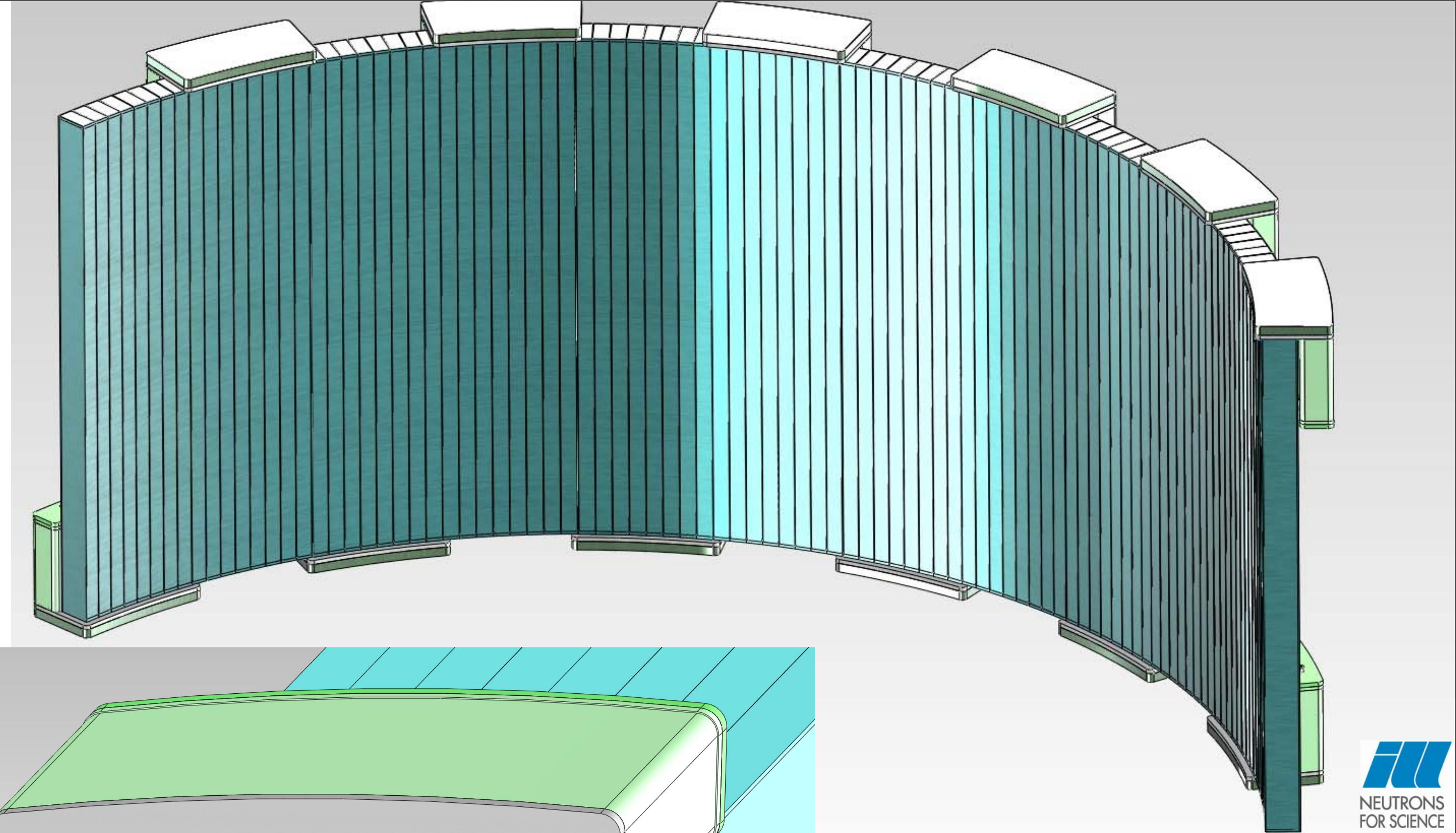


Installed this week on IN6 instrument
in-situ demonstration of performance



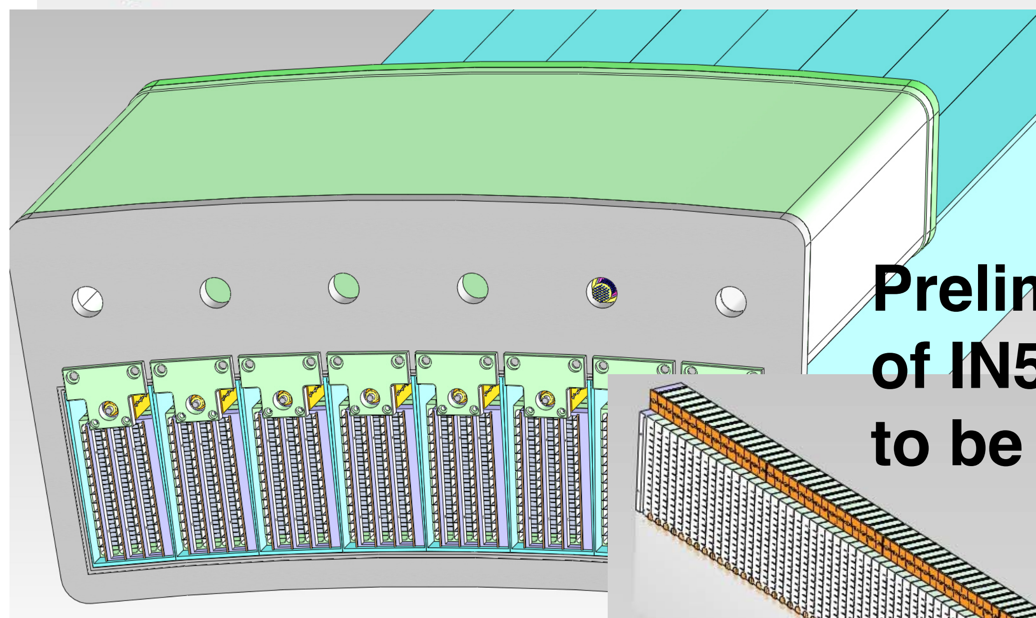
Log scale

What might a Cold Chopper Spectrometer look like for ESS?



Coincidence:

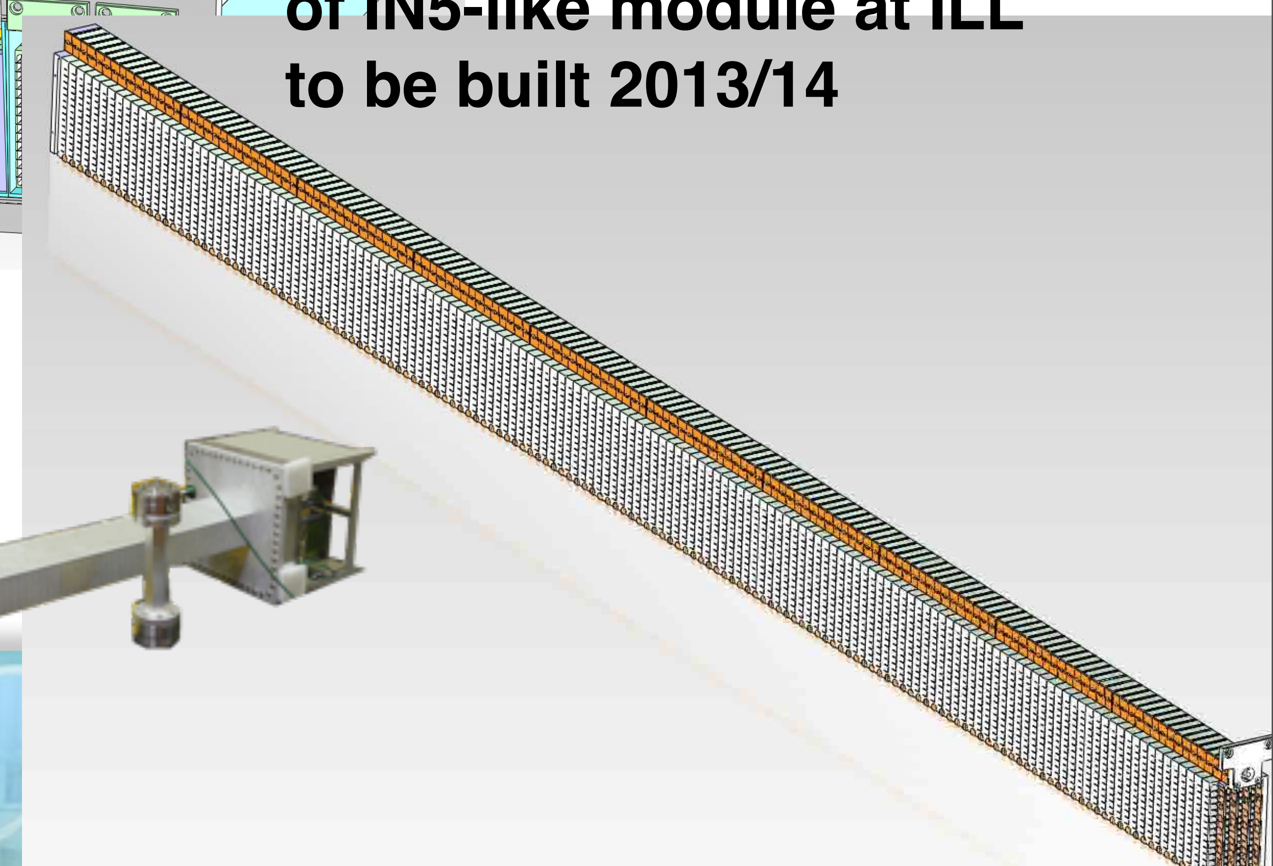
- 200 stacks, 10cm wide
- Each stacks needs to look for (x,z)-y coincidences
- x-z: 150 anode wires
- y: 200 grid-cathodes



- Significant number of readout cards or crates needed

- Significant number of data sources for detector data

Preliminary study for prototype of IN5-like module at ILL to be built 2013/14



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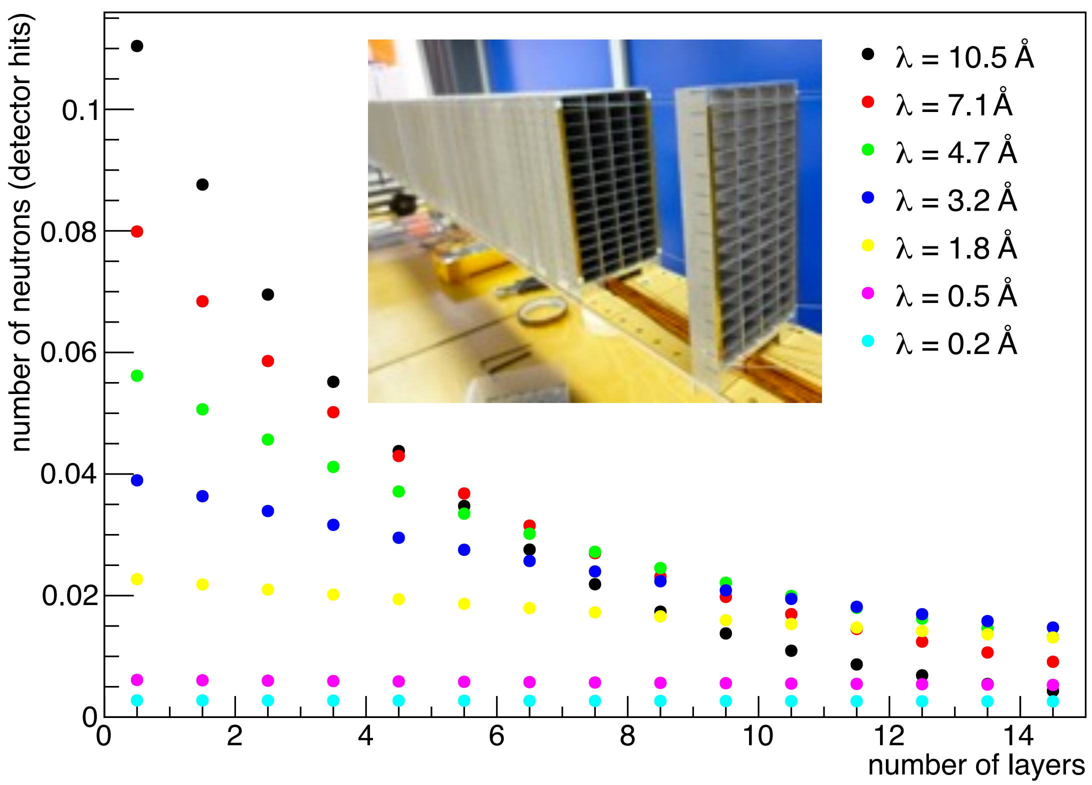
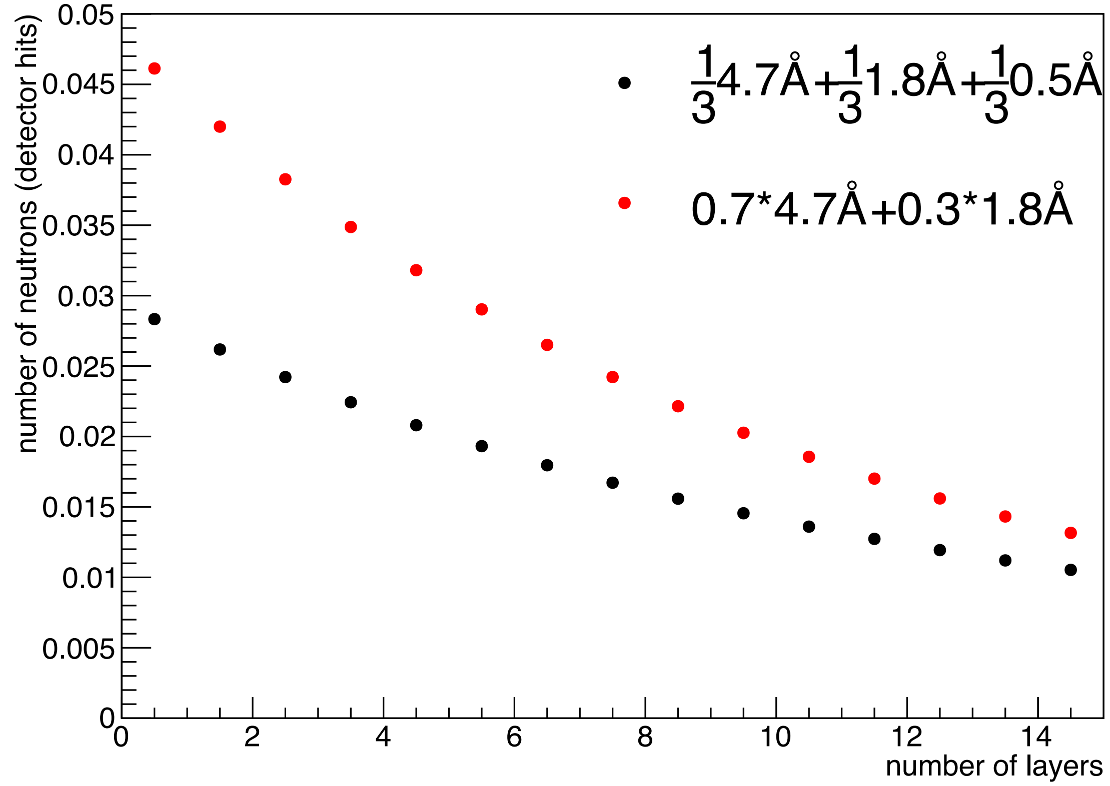
Neutron energy determination using statistical methods





VETENSKAPSRÅDET
THE SWEDISH RESEARCH COUNCIL

2012-22783-98161-69

2012
Project Research Grant - Statistics in the Empirical Sciences

Area of science
The Swedish Research Council
Announced grants
Thematic grants VR April 24 2012
Total amount for which applied (kSEK)

2013	2014	2015	2016	2017
1412	1459	1534	1573	1626

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Position
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Awarded - 0.6 researcher + 1 PhD

Mathematical approach on discriminating wavelength admixtures from the shape of the measured neutron spectrum, 6-8 months prototype preparation for testing

Another Analogy: the Research and Development as now ...

- About 530M years ago was the "Cambrian explosion"
- Sudden and quick increase in variety of life
- Sudden expansion into an empty niche?

- After an extinction event, types of species much less varied
- More-or-less the ancestors of what we have today

- There has been an explosion of detector types following the He-3 crisis
- In the long term it is likely to settle down to a few categories
- Hard to pick the winners today ...
- This is fun. Lots of work in the next 10 years++

Summary

- European Spallation Source: will be world's leading neutron source for study of materials
- ESS will produce first neutrons in 2019

- Technical Design Report being written - completion: February 2013
- Baseline instrument suite presented
- Four instruments proposed in 1st round of yearly proposals for instruments

Common for all detector needs:

- "Good" efficiency - not too much lower than He-3 equivalents
- Low "background" (noise, gamma rejection, scattering, ...) defines performance for many of the instruments
- In general large areas are needed and high number of detector readout channels
- The higher brightness means that care must be taken to avoid saturation of detectors
- Time resolution needed due to the use of time of flight of the neutrons

Detectors for instruments:

- A lot of progress within the last year
- A range of solutions are needed - unlikely to be just one replacement
- For large area detectors, key element is reducing detector cost/m^2
- A lot of development work still needed
- Need to demonstrate real performance on real instruments

Looks possible to eliminate need for He-3 for many ESS instruments ...

thank you and any questions ... ?